INDIAN JOURNAL OF SUGARCANE RESEARCH AND DEVELOPMENT

VOLUME IV PARTS 1 TO 4

October 1959 to September 1960

PUBLISHED BY
The Indian Central Sugarcane Committee,
(Ministry of Food & Agriculture, Government of India),
New Delhi,
1960

INDIAN JOURNAL OF SUGARCANE RESEARCH & DEVELOPMENT

SUBJECT INDEX

Vol. IV—Parts 1-4

INDIAN JOURNAL OF SUGARCANE RESEARCH & DEVELOPMENT

AUTHOR INDEX

Vol. IV—Parts 1-4

ADVERTISERS' INDEX

Vol. IV—Parts 1-4

About Ourselves

With the present issue, the Indian Journal of Sugarcane Research & Development (Quarterly) enters upon the fourth year of its successful publication and useful service. The Journal has served as an important media for disseminating among the various interests concerned the result of Sugarcane Research and Development work done in the country. During the past years it has tried to maintain its standard while catering to the varied needs of the progressive Sugarcane Cultivators, manufacturers and the Research & Development workers.

We take this opportunity to acknowledge with thanks the whole-hearted co-operation and support extended to us by the Sugarcane workers and distinguished scientists through their useful contributions to the Journal. We also gratefully acknowledge the consistent assistance, even at great personal inconvenience, given by members of the Editorial Board and the Referees in scrutinising the papers published in the Journal.

EDITOR

Here's what we can offer to the Cane Grower:

1. **Malamar (Malathion) for Mealy Bugs, White Flies and Mites.**
2. **Toxaphene/BHC for Lygaeid Bug.**
3. **Endrin for the Cane Leaf hopper or Pyrilla and Top Shoot Borer.**
4. **Ryania/BHC and Paramar (Parathion) for Cane borers.**
5. **Chlordane, a powerful soil insecticide for Termite and root Borer control.**
6. **Hexasan, the new organo mercurial seed-dressing for improving germination and obtaining increased yields.**
7. **2-4-D and PCP weed-killers for the eradication of both the grassy and broad-leaved types of weeds. Can be used safely for both post and pre-emergence spraying.**

We have a complete answer to all your
Cane problems in

HEXAMAR

Quality Controlled Products

For full details, write to:

BHARAT PULVERISING MILLS (PR.) LTD.,
Hexamar House, 38–A, Sayani Road,
Bombay—28

or

589, Thiruvottiyur High Road,
Madras—19

or

RALLIS INDIA LTD.,
Rallis House, 320, Linghi Chetty Street,
Madras—1
Sole Selling Agents for South India

or

JARDINE HENDERSON LIMITED,
4, Clive Row, Calcutta.
Sole Selling Agents for North-East India

or

MR. D. N. TANDON,
53/71, Western Extension Area,
Karol Bagh, New Delhi for North India.

Stockists throughout India.

EFFECT OF PHOSPHORUS DEFICIENCY ON THE CARBOHYDRATE FRACTIONS OF COMPONENT PARTS OF SUGARCANE AT SUCCESSIVE STAGES OF GROWTH

By

K. N. Lal and J. N. Singh*

(College of Agriculture, Banaras Hindu University, Banaras)

Introduction

Deficiency of phosphorus has been shown to bring about marked variations in the mineral composition of the sugarcane plant (Singh, 1955). Significant variations in the content of amide, nitrate, total soluble nitrogen and protein nitrogen were observed when this element was withheld from the culture medium (Lal and Singh, 1958). It is intended to present information on the effects of phosphorus deficiency on the carbohydrate fractions of sugarcane with a view to explain the manner in which phosphates affect carbohydrate metabolism of sugarcane at successive stages of growth.

Experimentation

To assess the nature, amount and significance of such variations in carbohydrate fractions, sugarcane was grown in sand nutrient cultures under conditions of complete nutrition and P-deficiency (Singh, 1955). Parallel data on the effects of phosphate fertilization in soil cultures were also collected. The experiment in soil cultures was conducted during the year 1954 when besides the concentrations used in earlier investigations (Singh, 1955) viz., 0-80 ppm. an additional dose of 160 ppm. was also tried. The experiment in short involved a study of the effect of six levels of phosphate fertilization on the carbohydrate fractions of leaf, stem and root during the pre-monsoon, monsoon and post-monsoon stages of sugarcane growth.

The plant materials, including leaf, stem and root from these experiments were collected at specified stages of the growth of sugarcane viz., at 45, 90, 135 and 225 days in the sand nutrient cultures and at pre-monsoon (June), monsoon (September) and post-monsoon (December) stages in soil cultures. The samples thus collected were weighed on a chemical balance to the nearest milligram, immediately killed in boiling 80 per cent alcohol and preserved in stoppered bottles. Estimations of glucose, fructose, total reducing sugars, sucrose and total sugars were made in these samples. Fructose was estimated by the Jackson and Mathew's modification of Nyn's method using Ost solution, as described by Loomis and Shull (1937). Reducing sugars were estimated on the cleared and deleaded extract by the Lane and Eynon's method using methylene blue as an internal indicator (A.O.A.C. 1945). Total sugars were estimated on the acid hydrolysed extract by the Lane and Eynon's method. Glucose was calculated by subtracting the value of fructose from total reducing sugars. The values for both glucose and fructose were corrected as suggested by Loomis and Shull (1937). Sucrose was estimated by subtracting the value of reducing sugars from total acid hydrolysable sugars and multiplied by 0·95 to correct for water taken up during hydrolysis. All these values have been expressed as percentages of fresh material.

The data, thus collected, were statistically analysed in each case and stress laid on the most outstanding effects noted in different directions.

Experimental Findings

A. *Sand Culture:*

(i) *Fructose :* The fructose content varied to a certain extent with the condition of nutrition and the age of plants. A general tendency of decline in fructose content of leaf towards maturity under both phosphorus deficiency and complete nutrition was recorded. Highest fructose in leaf was noted at 135 days in phosphorus-deficient and at 90 days in complete-nutrient canes. In stem, fructose content increased with advance in age, reaching the highest level at 225 days under complete nutrition and at 135 days under phosphorus-deficiency conditions. The roots showed relatively poor fructose content and contained only traces of fructose during early stages (45-90 days) in the life cycle in the complete nutrition canes (Table I).

*Now Assistant Professor of Agriculture, Bihar Agriculture College, Sabour.

Statistical analysis of the data revealed the outstanding effect of plant parts on the fructose content. The effects of age, phosphorus-deficiency, interactions between age and treatments, and between treatments and plant parts were insignificant (Table II). Taking the over-all plant part values into consideration, no significant differences between the complete-nutrient and phosphorus-deficient cultures was recorded. Similarly increase in age also failed to show any significant variation in the fructose content of the plant (Table IIIA). The stem invariably showed a significantly higher fructose content than the leaf or the root of the complete-nutrient plants but the differences in the fructose content of component parts were not significant under phosphorus deficiency. The average response of the two cultures, however, indicated the pronounced increase in fructose content of the stem over that of the other two organs (Table IVA).

TABLE I

Effect of phosphorus deficiency on the carbohydrate fractions of component parts of sugarcane (var. Co. 453) under sand nutrient cultures

(gms. per 100 gms. fresh weight)

Age in days	Treatments	Fructose	Glucose	Reducing Sugars	Sucrose	Total sugars
		A. *Leaf*				
45	CN	0·024	0·098	0·122	0·924	1·095
	–P	0·039	0·104	0·143	0·917	1·080
90	CN	0·132	0·362	0·494	0·840	1·378
	–P	0·175	0·250	0·425	1·063	1·544
135	CN	0·092	0·194	0·286	0·655	0·976
	–P	0·183	0·222	0·405	0·757	1·307
225	CN	0·041	0·212	0·206	1·154	1·421
	–P	0·074	0·310	0·384	1·191	1·641
		B. *Stem*				
45	CN	0·208	0·194	0·357	1·535	1·973
	–P	0·140	0·141	0·281	1·311	1·661
90	CN	0·370	0·369	0·739	2·321	2·868
	–P	0·382	0·309	0·691	2·030	2·828
135	CN	0·715	0·730	1·445	3·188	4·801
	–P	1·089	1·048	2·137	4·625	7·005
225	CN	1·881	1·602	3·483	8·495	12·425
	–P	0·549	0·641	1·190	2·787	4·124
		C. *Root*				
45	CN	0·095	0·094	0·189	0·692	0·917
	–P	0·090	0·098	0·188	0·789	1·019
90	CN	0·056	0·086	0·142	0·813	0·998
	–P	0·102	0·022	0·124	0·984	1·160
135	CN	0·000	0·126	0·126	0·649	0·809
	–P	0·000	0·142	0·142	0·534	0·704
225	CN	0·000	0·112	0·122	0·845	1·012
	–P	0·097	0·037	0·242	1·960	2·305

TABLE II

General response of age, treatments, plant parts and interactions on the sugar fractions of sugarcane (var. Co. 453) under sand nutrient cultures

Analysis of Variance

Due to	D. F.	M. S. S.				
		Fructose	Glucose	Reducing Sugars	Sucrose	Total Sugars
Age	3	0·1370	0·1647	0·6288	3·3209	7·2863
Treatments	1	0·0202	0·0304	0·0769	0·4161	0·7586
Plants parts	2	0·9370*	0·6349*	3·0215*	14·8965*	32·7133*
Age × Treatments	3	0·0864	0·0492	0·2346	1·1272	2·6417
Treatments × Plant parts	2	0·0574	0·0214	0·1522	1·3321	2·3851
Error	12	0·1303	0·0904	0·4407	1·9900	4·3901
Total	23	..	..	..	..	..
S.E./observation..	..	±0·36	±0·3006	±0·664	±1·392	±2·094

*Significant at 5% level.

TABLE III

Effect of age on the carbohydrate fractions of complete nutrient and phosphorus-deficient sugarcane (var. Co. 453) under sand nutrient cultures

Age × Treatment Interactions

Treatments	Age in days				Mean of 12 values	C.D. at 5% for mean of
	45	90	135	225		
			A. *Fructose*			
CN	0·109	0·186	0·269	0·641	0·301	3 values = ±0·6405
-P	0·089	0·220	0·424	0·240	0·243	6 „ = ±0·4524
Mean of 6 values	0·993	0·203	0·347	0·440	..	12 „ = ±0·3199
			B. *Glucose*			
CN	0·129	0·272	0·350	0·642	0·348	3 values = ±0·4624
-P	0·114	0·194	0·471	0·329	0·277	6 „ = ±0·3269
Mean of 6 values	0·122	0·233	0·410	0·486	..	12 „ = ±0·2668
			C. *Reducing Sugars*			
CN	0·223	0·458	0·619	0·270	0·643	3 values = ±1·1928
-P	0·204	0·413	0·895	0·605	0·529	6 „ = ±0·8024
Mean of 6 values	0·213	0·436	0·757	0·938	..	12 „ = ±0·5957
			D. *Sucrose*			
CN	1·050	1·325	1·497	3·498	1·843	3 values = ±2·5049
-P	1·006	1·359	2·005	1·980	1·588	6 „ = ±0·7691
Mean of 6 values	1·028	1·342	1·751	2·739	..	12 „ = ±1·2309
			E. *Total Sugars*			
CN	1·328	1·748	2·195	4·953	2·556	3 values = ±3·7255
-P	1·263	1·844	3·005	2·690	2·201	6 „ = ±2·6311
Mean of 6 values	1·296	1·796	2·600	3·621	..	12 „ = ±1·8605

TABLE IV

Effect of nutritional conditions on carbohydrate fractions of component parts of sugarcane (var. Co. 453) under sand nutrient cultures

Treatments	Plant Parts: Leaf	Plant Parts: Stem	Plant Parts: Root	Mean of 12 values	C.D. at 5% for mean of	
			A. Fructose			
CN	0·072	0·794	0·038	0·3012	4 values	= ±0·5543
–P	0·118	0·540	0·072	0·2433	8 ..	= ±0·3922
Mean of 8 values	0·095	0·667	0·055	..	12 ..	= ±0·3199
			B. Glucose			
CN	0·217	0·724	0·105	0·348	4 values	= ±0·4624
–P	0·222	0·535	0·075	0·277	8 ..	= ±0·3264
Mean of 8 values	0·219	0·629	0·090	..	12 ..	= ±0·2668
			C. Reducing Sugars			
CN	0·277	0·506	0·145	0·643	4 values	= ±1·0322
–P	0·339	1·075	0·174	0·529	8 ..	= ±0·7289
Mean of 8 values	0·308	1·290	1·159	..	12 ..	= ±0·5957
			D. Sucrose			
CN	0·893	3·885	0·775	1·843	4 values	= ±2·1677
–P	1·008	2·688	1·067	1·588	8 ..	= ±1·5329
Mean of 8 values	0·951	3·287	0·903	..	12 ..	= ±1·2309
			E. Total Sugars			
CN	1·218	5·517	0·934	2·556	4 values	= ±3·2339
–P	1·400	3·905	1·297	2·201	8 ..	= ±2·2814
Mean of 8 values	1·309	4·711	1·116	..	12 ..	= ±1·8605

(ii) *Glucose:* The glucose content of the leaf was highest at 90 days in the complete-nutrient plants (Table I); under phosphorus deficiency high value was recorded at 225 days. Complete-nutrient and phosphorus-deficient cultures showed the highest glucose content of the stem at 225 days and 135 days respectively. In the roots, glucose content did not vary so markedly but relatively high values were recorded under both these cultures at 135 days of the life cycle. It also appeared that the content of this sugar fraction was relatively high in the stem as compared to other organs at various stages of the life cycle (Table I). Statistical analysis further confirmed the outstanding effect of plant parts in altering the glucose content. Other main effects and interactions were not significant (Table II). The average response depicted an increase in the glucose content with advance in age reaching significantly high values at maturity in comparison to the glucose content recorded at 45 days. The differences in glucose content at successive periods were not significant. It was also evident that phosphorus deficiency did not exhibit any significant reduction in the glucose content of the tissues (Table IIIB). The stem again showed a significantly high glucose content in comparison to other two organs but no significant variations between the glucose contents of the leaf and root were recorded (Table IVB).

(iii) *Total Reducing Sugars:* Total reducing sugars of the component parts also exhibited a similar trend of variation. Thus the leaf showed the highest reducing sugar content at 90 days in the life cycle in both

the complete nutrition and phosphorus deficiency cultures and thereafter indicated reduction in this sugar fraction with advance in age. The stem showed the highest reducing sugar content at 225 days in complete nutrition and at 135 days in phosphorus deficient cultures. In roots, the variations were of lesser significance at various periods of growth. There was noted a gradual fall in reducing sugar content with age in the complete nutrition plants. In P plants, the fall in reducing sugar was noted up to 135 days only; thereafter reducing sugars accumulated due to possible interference in the further elaboration of these sugars when concentration of absorbed phosphates fell down below a certain level. (Table I).

Statistical analysis of the data showed that plant parts did not alter the content of total reducing sugars significantly. Other main effects and interactions were also not significant (Table II). The over-all plant parts values, however, showed a general tendency of high total reducing sugar content at 135 days, but the variation recorded at successive samplings were not significant in both the complete-nutrient and the phosphorus-deficient cultures. The average response of the age and of phosphorus deficiency also showed a similar tendency (Table IIIC). So far as the stem was concerned, the average response indicated a significant increase in total reducing sugars over the values recorded either for the leaf or the roots. Under phosphorus deficiency or complete nutrition, although this tendency was still evident, the differences between the component parts were not significant (Table IVC).

(iv) *Sucrose:* In general, the sucrose content of leaf declined to low value at 135 days in CN plants and thereafter rose to a high level at maturity. In the deficient plants the sucrose content increased at 90 days, declined to a low value at 135 days and again rose to a high level at 225 days. The first rise is attributed to the higher uptake of phosphates at 135 days and its possible role in the formation of sucrose. In stem, the complete-nutrient cultures exhibited the highest sucrose content at 225 days, but the phosphorus-deficient plants showed relatively high sucrose at 135 days and then there was a drop. In roots, the highest sucrose content was recorded in minus-phosphorus and complete nutrition plants at maturity (Table I). Low sucrose was recorded in both these cultures at 135 days and a tendency of relatively high sucrose was also noted at 90 days. Phosphorus deficiency thus showed different responses on the sucrose content of component organs at various periods of growth.

Analysis of variance showed once again that sucrose content varied significantly with the plant parts but failed to indicate any significant variation with either the age or the nutritional condition. Interactions between age and treatments, and between treatments and plant parts were also insignificant (Table II). The over-all plant parts values also indicated significant variations with either age or phosphorus deficiency. A tendency of improvement in sucrose at maturity over the values recorded at 45 days in the life cycle, was however evident (Table IIID). The over-all age values, however, indicated significantly high sucrose content of the stem over that of the other two organs of the complete nutrient plants. Under deficiency conditions, however, differences in sucrose content of leaf, root and stem were not significant (Table IVD).

(v) *Total Sugars:* Total sugars content of the stem also increased with advance in age reaching high values at 135 days in phosphorus-deficient and at 225 days in the complete-nutrient plants. In leaf, the content of total sugars was highest at 225 days in both -P plants and CN plants; in roots the variations with age were not so characteristic. A general tendency of low total sugars at 135 days in both CN and –P plants and of a high value in –P plants at 225 days in the life cycle was noted. (Table I). Plant parts were again significant in altering the total sugar content. Effects of other factors were usually insignificant. (Table II). Differences due to either phosphorus deficiency or age were usually insignificant (Table IIIC). It was only when the over-all age values were taken into consideration that the stem exhibited a relatively high total sugar content than the leaf or the root of the complete-nutrient plant. This tendency also existed in phosphorus-deficient cultures but the differences in total sugar content of the three organs were not significant (Table IVE).

B. *Soil Cultures:*

(i) *Total Reducing Sugars:* In the soil series, variations in total reducing sugars of component parts of sugarcane were recorded under different levels of phosphorus fertilization. During the pre-monsoon and post-monsoon stages, the variation recorded appeared to be very significant (Table VA). Age and the component parts showed significant effects on the total reducing sugars content. The effects of phosphorus fertilization and of the interactions between age and nutrition, and between treatments and plant parts were insignificant (Table VI). The pre-monsoon canes were richer in total reducing sugars than either the monsoon or post-monsoon canes. Significant reduction in total reducing sugars was recorded during post-monsoon period in comparison to the pre-monsoon stage. The variations in total reducing sugars with various levels of phosphates were not significant (Table VIIA). It was also evident that the roots were the poorest in the total reducing sugars content while the stem was the richest. The leaf occupied an intermediate position between the two. The average response indicated significant differences in the total reducing sugar content

of the three organs. The effects of various concentrations of phosphorus were again not very characteristic in any of the three organs (Table VIIIA).

TABLE V

Effect of increasing doses of P_2O_5 on carbohydrate fractions of component parts of sugarcane (var. Co. 453) under soil cultures

(gms. per 100 gms. fresh weight)

Stages	Plant parts	0	Concentration of P_2O_5 in ppm. of soil				
			20	40	60	80	160
			A. *Reducing Sugars*				
Pre-monsoon	Leaf	1·1823	1·2272	1·0344	1·1883	0·8666	1·1181
	Stem	1·0136	1·3138	1·2647	1·2490	1·2153	1·1108
	Root	0·2764	0·3015	0·0354	0·2917	0·2991	0·3125
Monsoon ..	Leaf	0·1420	0·3170	0·2875	0·3395	0·3302	0·3205
	Stem	1·2707	0·9698	1·2497	1·4112	1·2603	1·6891
	Root	0·1061	0·1348	0·1118	0·1084	0·1512	0·1373
Post-monsoon	Leaf	0·3219	0·2928	0·2739	0·2722	0·2746	0·3687
	Stem	0·8049	0·8385	0·8029	0·8670	0·9930	0·9227
	Root	0·0930	0·1196	0·0904	0·1462	0·1851	0·1095
			B. *Sucrose Content*				
Pre-monsoon	Leaf	1·0964	1·0768	0·9529	0·6168	1·2158	0·7813
	Stem	1·9682	1·5279	1·3839	1·3676	1·4158	1·9313
	Root	0·7995	0·7021	0·4731	0·4966	0·6574	0·4018
Monsoon ..	Leaf	0·9221	1·2376	0·8881	0·9421	0·8800	1·0498
	Stem	8·3105	7·9135	8·2317	7·4595	7·0129	6·5850
	Root	1·2852	0·9996	1·1081	0·9415	1·0864	0·7680
Post-monsoon	Leaf	1·4883	1·7943	1·4393	1·7858	1·5176	1·6649
	Stem	12·6993	11·8461	12·7481	12·7320	12·9504	12·7313
	Root	1·1525	1·1401	0·8550	0·9167	1·2379	1·0400
			C. *Total Sugars*				
Pre-monsoon	Leaf	2·3364	2·3607	2·0375	1·8365	2·1462	1·9405
	Stem	3·0854	2·9221	2·7215	2·6886	2·7056	3·1438
	Root	1·1180	1·0441	0·7334	0·8144	0·9911	0·7354
Monsoon ..	Leaf	1·1126	1·6199	1·2224	1·3312	1·2565	1·4255
	Stem	10·0184	9·2998	9·9147	9·2633	8·6423	8·6207
	Root	1·4589	1·1870	1·2782	1·0995	1·2948	0·9458
Post-monsoon	Leaf	1·8385	2·1815	1·8970	2·1520	1·8721	2·1212
	Stem	14·1723	13·3081	14·2220	14·2691	14·6250	14·3241
	Root	1·3062	1·2197	0·9904	1·1111	1·4882	1·2042

TABLE VI

General response of age, treatments, plant parts and interactions on carbohydrate fractions of sugarcane (var. Co. 453) under soil cultures

Analysis of Variance

Due to	D. F.	M. S. S.		
		Reducing Sugars	Sucrose	Total sugars
Age	2	0·8608*	73·8615*	66·1174*
Treatments	5	0·0119	0·1036	0·0601
Plant parts	2	4·0754*	233·1394*	322·7487*
Age × Treatments	10	0·0122*	0·1175	0·1077
Treatments × Plant parts	10	0·0084	0·0550	0·0928
Error	24	0·0770	9·2445	10·6584
TOTAL	53	..	..	..
S.E./observation	..	±0·27	±3·04	±3·26

*Significant at 5% level.

TABLE VII

Effect of levels of P_2O_5 and age of the plant on the carbohydrates fractions of sugarcane (var. Co. 453) under soil cultures

Treatments × Stages Interactions

Stages	Concentration of P_2O_5 in ppm. of soil						Mean of 18 values
	0	20	40	60	80	160	
			A. *Total Reducing Sugars*				
Pre-monsoon ..	0·8241	0·9487	0·8448	0·9097	0·7937	0·8471	0·8613
Monsoon ..	0·5063	0·4739	0·5497	0·6197	0·5806	0·7157	0·5743
Post-monsoon ..	0·4066	0·4167	0·3891	0·4285	0·4842	0·4670	0·4321
Mean of 9 values	0·5790	0·6132	0·5945	0·6526	0·6195	0·6766	..
C.D. at 5% for means of 3 values=±0·5771; 9 values=±0·2639; 18 values=±0·1857							
			B. *Sucrose*				
Pre-monsoon ..	1·2880	1·1023	0·9366	0·8267	1·0963	1·0381	1·0480
Monsoon ..	3·5959	3·3836	3·4093	3·1144	2·9931	2·4009	3·2012
Post-monsoon ..	5·1134	4·9268	5·0141	5·1448	5·2353	5·1453	5·0966
Mean of 9 values	3·3024	3·1376	3·1200	3·0285	3·1082	2·9948	..
C.D. at 5% for means of 3 values =±5·1163; 9 values=±2·9552; 18 values=±2·0915							
			C. *Total Sugars*				
Pre-monsoon ..	2·1799	2·1090	1·8308	1·7798	1·9476	1·9399	1·9645
Monsoon ..	4·1966	4·0356	4·1384	3·8980	3·7312	3·6640	3·9940
Post-monsoon ..	5·7890	5·6031	5·6671	5·8441	5·9951	5·8832	5·7969
Mean of 9 values	4·0552	3·9159	3·8788	3·8406	3·8913	3.8990	..
C.D. at 5% for means of 3 values =±5·4396; 9 values=±3·1584; 18 values=±2·2385							

TABLE VIII

Mean effect of levels of P_2O_5 and component parts of the plant on carbohydrate fractions of sugarcane (var. Co. 453) under soil cultures

Treatments × Plant Parts Interactions

Plant Parts	Concentration of P_2O_5 in ppm. of soil						Mean of 18 values
	0	20	40	60	80	160	
			A. *Total Reducing Sugars*				
Leaf	0·5487	0·6123	0·5319	0·6000	0·4905	0·6024	0·5643
Stem	1·0297	1·0407	1·1058	1·1757	1·1562	1·2409	1·1248
Root ..	0·1585	0·1865	0·1459	0·1821	0·2118	0·1865	0·1785
Mean of 9 values	0·5790	0·6132	0·5945	0·6526	0·6195	0·6766	..
C.D. at 5% for means of 3 values=±0·5771; 9 values=±0·2639; 18 values=±0·1857							
			B. *Sucrose*				
Leaf	1·1689	1·3696	1·0934	1·1146	1·2044	1·6513	1·1861
Stem	7·6593	7·0958	7·4546	7·1864	7·1264	7·0826	7·2675
Root ..	1·0791	0·9473	0·8121	0·7849	0·9939	0·7366	0·8923
Mean of 9 values	3·3024	3·1376	3·1200	3·0286	3·1082	2·9948	..
C.D. at 5% for means of 3 values=±5·1162; 9 values=±2·9552; 18 values=±2·0915							
			C. *Total Sugars*				
Leaf	1·7792	2·0540	1·6830	1·7732	1·7583	1·8297	1·8128
Stem	9·0920	8·5100	1·9527	8·7403	8·6576	9·6962	8·7748
Root	1·2944	1·8136	1·0007	1·0083	1·2580	0·9618	1·1178
Mean of 9 values	4·0552	3·9159	3·8788	3·8408	3·8913	3·8290	..
C.D. at 5% for means of 3 values=±5·4396; 9 values=±3·1584; 18 values=±2·2385							

(ii) *Sucrose:* The sucrose content of the leaf, stem and the root also showed marked variations under different levels of phosphates. The variations in the relative sucrose content of the three organs under various phosphorus levels were of lesser significance during the pre-monsoon period but became most prominent during the post-monsoon period. It was also clear that the stem was invariably richer in sucrose content than the other two organs particularly during later growth stages (Table VB). Statistical analysis again confirmed the high significant effect of the stage of growth and the component parts in altering the concentration of sucrose (Table VI). While age improved sucrose content, phosphate fertilization was not so effective in altering this fraction of carbohydrates (Table VIIB). Highly significant increases in sucrose content of stem relative to that of the leaf and the root were observed (Table VIIIB).

(iii) *Total Sugars:* Total sugars also showed more or less similar trend of variation with the level of fertilization, component parts, or the stages of growth. Once again, the plant parts and age showed the most outstanding effect in that the stem was highest in total sugars content in comparison to both leaves and roots particularly during the monsoon and the post-monsoon stages (Table VC; VI). No significant differences due to successive levels of fertilization were noted either during pre-monsoon, monsoon or post-monsoon stages of growth, but increase in age significantly raised the total sugar content (Table VIIC). Such increases were most apparent in the stem in comparison to the leaf or the root which indicated no significant variations (Table VIIIC).

Discussion

Effect of Phosphorus Deficiency:

Withholding supply of phosphorus from the culture medium exhibited no significant difference in fructose, glucose, total reducing sugars, sucrose and total sugars content of the sugarcane plant. Even at the most critical stages of carbohydrate accumulation in the dry matter, viz., at 45-90 days, very little difference in fructose, glucose, sucrose and total sugars content under phosphorus deficiency was noted. At maturity, however, the concentration of sucrose, total sugars and reducing sugars in dry matter of –P plants was lowered (Fig. 1). It may be recalled that under phosphorus deficiency amides and other soluble nitrogenous compounds in this plant accumulated along-side an increase in nitrogen content (Lal and Singh, 1958). Sulphur was absorbed and accumulated in deficient cultures (Singh, 1955). To what extent such accumulation helped in the metabolism of carbohydrates and proteins in sugarcane requires thorough analysis. Evidences do indicate that deficiency of this element affected the nitrogen metabolism more than the metabolism of carbohydrates (Lal and Singh, 1958). If at all effective, its absence lowered sucrose and total sugars and raised reducing sugars at maturity indicating thereby that further elaboration of hexoses was hampered when this element was withheld.

Effect of Phosphorus Fertilization:

Phosphate fertilization induced some variation in the percentage of total reducing sugars, sucrose and total sugars. Thus the content of total reducing sugars showed some increase with each addition of phosphate during the monsoon and post-monsoon periods. During pre-monsoon stage, however, the effects were inconsistent. A general tendency of higher doses of phosphate in raising reducing sugars during adolescence was thus obvious. Sucrose and total reducing sugars failed to show any marked improvement over the control. Effect of various levels of phosphorus on the sugar content of component organs did not vary appreciably in majority of the cases. Phosphate fertilization, therefore, if effective at all, favoured the accumulation of reducing sugars more than either sucrose or total sugars particularly towards the later periods of the life cycle (Fig. 2). It failed to show any useful effect on the sucrose content of component parts.

Effect of age:

Age showed significant effects on various sugar fractions. Thus under sand nutrient cultures, maximum quantity of fructose, glucose, total reducing sugars, sucrose and total sugars accumulated towards maturity. It was at this stage of 225 days that the increase in some of these sugar fractions attained high values in comparison to the values recorded at 45 days. What led to increase in the accumulation of sugars towards maturity when the photosynthesis per unit leaf area was reduced to a low level and when total leaf area per plant also showed marked decline, needed careful investigation. It appeared that such an accumulation during the later periods was not a direct effect of any increase in the rate of photosynthesis at this stage of life cycle but was due to—(i) the continuous process of slow accumulation of sugars in the stem at successive stages of growth, and (ii) the high efficiency of the invertase, phosphorylase and other enzymes at maturity which helped in the rapid conversion of the various simple sugars to sucrose. Direct evidence in the latter direction are, however, lacking.

Parallel investigations on other plants, however, showed that phosphorus deficient plants accumulated more of carbohydrates at certain critical stages of growth (Eaton, 1949, 50, 52). Two main explanations were given—(i) that phosphorus deficiency interfered with the protein synthesis at the nitrate reduction stage resulting in increase of both carbohydrates and nitrates, and (ii) interference with protein synthesis at the amide stage with the result that carbohydrates accumulated side by side with amides and amino acids. When the facts observed in the present investigations were judged on this basis, certain anomalies became obvious. Thus, deficiency of phosphorus no doubt showed some sort of interference with nitrate reduction but this was never accompanied by any increase in sugars. Similarly deficiency of phosphorus also resulted in the accumulation of amide and soluble nitrogen compounds but it failed to cause any improvement in sugars (Lal and Singh, 1958). In what manner the sugars were utilized under phosphorus deficient conditions and were not accumulated, required further investigation. Possibly the utilization of sugars in the organic acid metabolism in this plant particularly at maturity, may be one of the reasons for this abnormal behaviour in sugarcane. A thorough examination of organic acid metabolism of sugarcane, particularly at maturity is, therefore, necessary. If, as a result of such investigations, it is shown that part of the sugars were utilized in the formation of organic acids at maturity, the possibility of reducing such utilization may be exploited in raising the quality of sugarcane juice at harvest.

Effect of Component Parts:

Taking the various organs into consideration the variation in the carbohydrate fractions irresistibly led to these conclusions—(i) that the leaf although functioning as a principal organ for the synthesis of

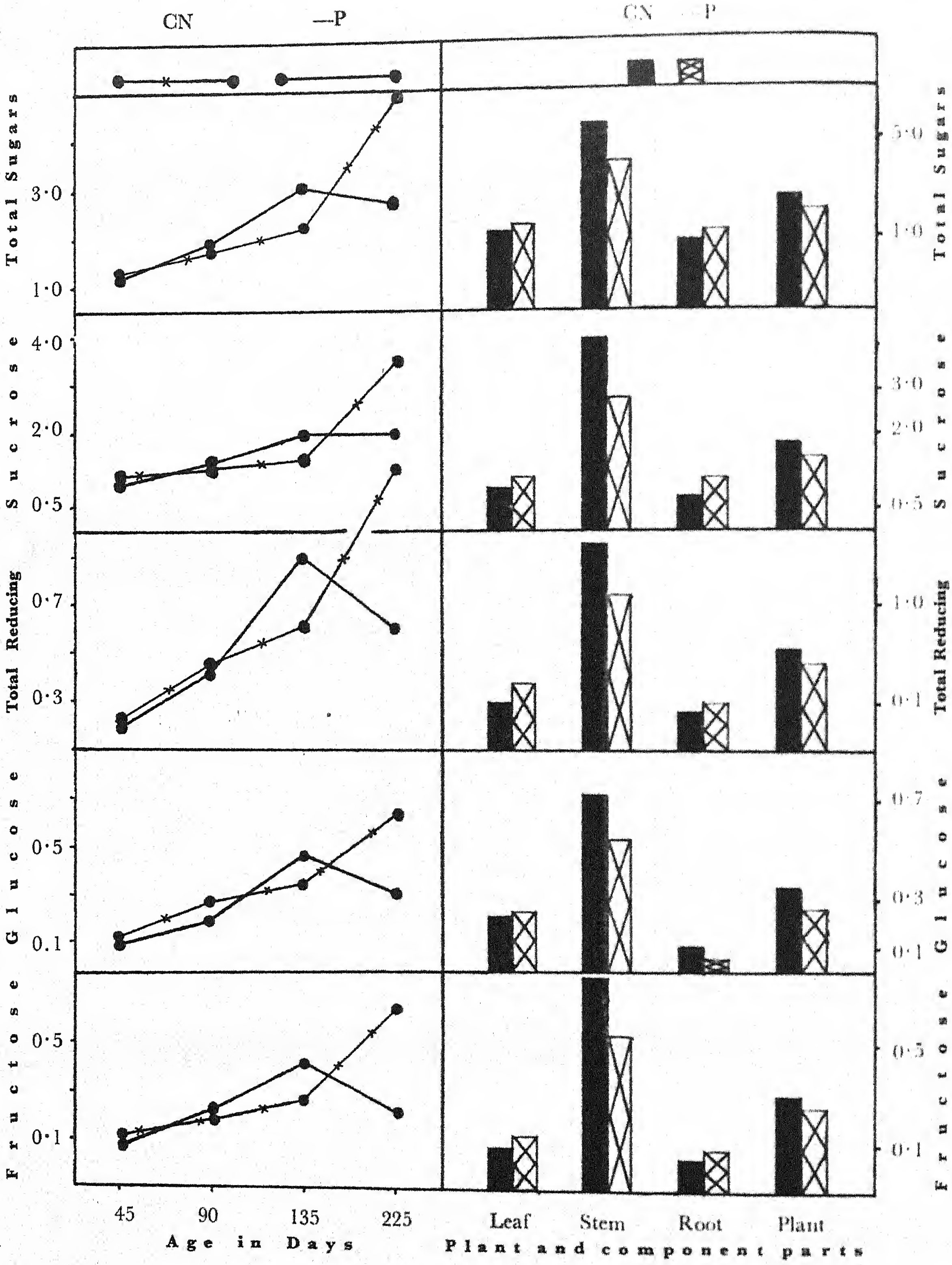


FIG. 1. Sugar fractions of component parts of sugarcane (Var. Co. 453) in relation to age and phosphorus deficiency in sand cultures.

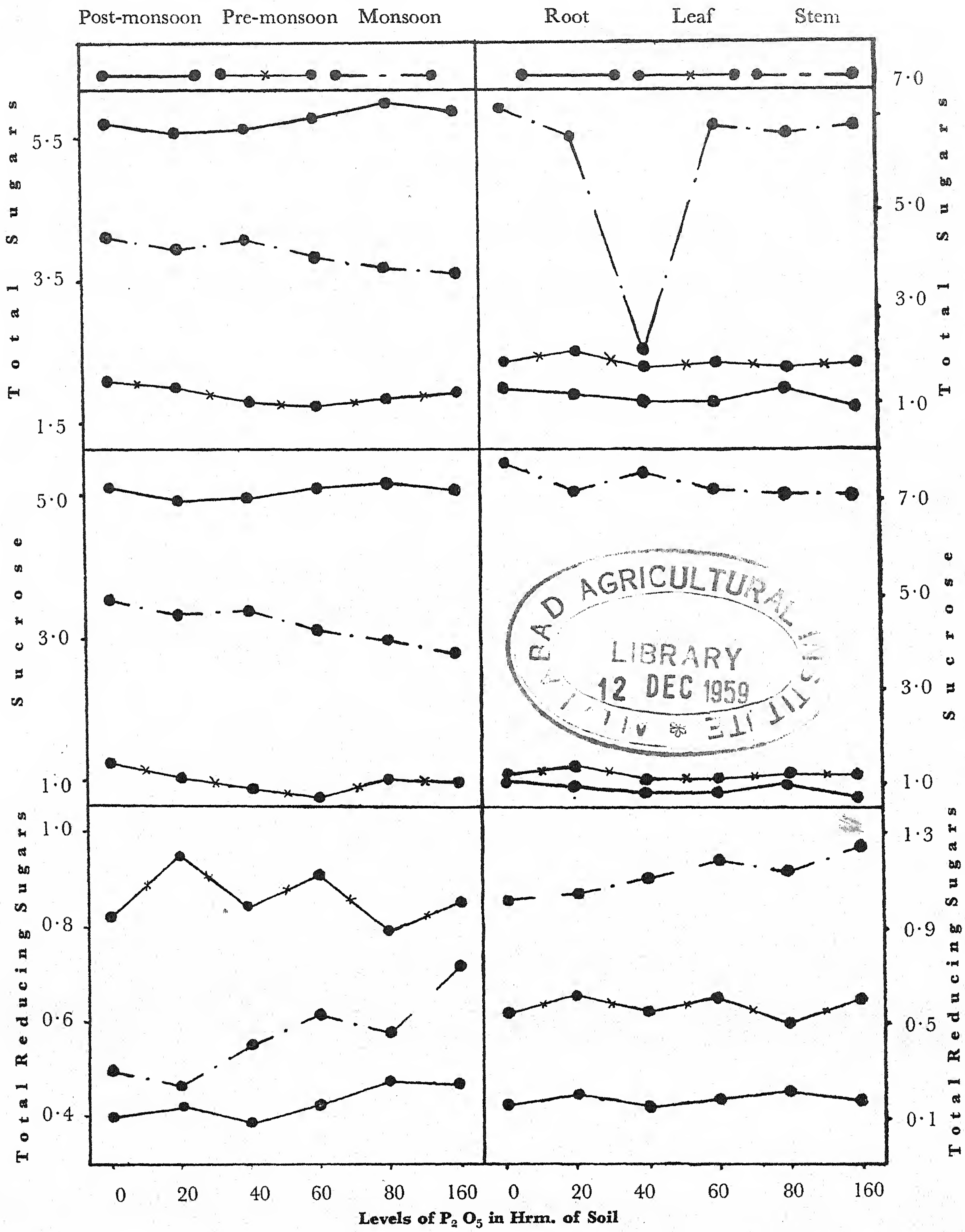


FIG. 2 Sugar fractions of component parts of sugarcane (Var. Co. 453) in relation to age and phosphorus application in soil cultures.

carbohydrate, failed to accumulate sugars beyond a certain critical concentration; (ii) that the stem served as the principal storage tissue from the very early stages in the life cycle; and (iii) that the roots did not function effectively to any large extent in bringing about increased accumulation of sugars.

Taking these facts into consideration along-side the well established concept of downward movement of carbohydrates through the phloem tissue, it becomes obvious that as the sugars moved down the sieve tubes, they were laterally distributed into the ground tissues of the stem and converted into some non-labile form which failed to migrate down to the roots as efficiently and quickly as the hexoses and other simpler sugars coming down from the leaf. The specific role of enzymes in bringing about such conversions of highly labile sugars into other less labile carbohydrates requires careful analysis. It is likely that such a study may provide the necessary link in explaining the mechanism of carbohydrate accumulation in the sugarcane stem.

Investigations on the movement of carbohydrates in cotton plant (Mason and Maskell. 1928a,b) showed that reducing sugars were present in the leaves greatly in excess of sucrose. In the boll, the excess of reducing sugars over sucrose was especially marked. In the stem, however, sucrose was in excess of the reducing sugar. The concentration of sucrose in the bark of the cotton plant increased during day and decreased during the night, while the reducing sugars remained relatively constant. Based on the relative concentration of these sugars it was suggested that movement of sugars down the stem towards the root resembled movement by simple diffusion in that the direction of the movement was from the region of high to one of low concentration. Sugars also moved through sieve tubes by a process of diffusion. It was noted that sucrose gradient between the bark and the boll was an important factor in determining changes in the rate of transport of carbohydrates through the pedicel to the boll.

In the synthesis of carbohydrates in sugarcane simple sugars, cane sugar, starch and polysaccharides were found to be interrelated. They fluctuated during day and night (Hartt, 1935). Formation of glucose or sucrose took place in all detached parts independent of light and chlorophyll. Cutting leaves into small pieces did not increase sucrose while grinding inhibited synthesis completely (Hartt, 1943). Experiments with respiratory inhibitors showed that in sugarcane enzyme systems essential for respiration were not essential for sucrose synthesis. Chemicals which interfere with the transference of phosphate from a phosphate compound to glucose interfered with synthesis of sucrose. Those which prevented breakdown of hexose-phosphate aided synthesis. Fructosediphosphate may be the stepping stone necessary for the formation of sucrose from glucose. Further, phosphorus was important in converting glucose to fructose and in the formation of sucrose. Inorganic phosphorus with glucose failed to improve efficiency of low phosphorus plants. Sucrose synthesis decreased by addition of phosphates with glucose solution but organic phosphorus proved helpful (Hartt, 1943).

Applied phosphates accelerated intake of nitrogen, phosphorus, potassium and calcium during early stages and uptake of phosphorus and potassium throughout the first year of cane growth. In the second year phosphorus fertilization gave the highest uptake of potassium. A narrow ratio of nitrogen/phosphorus was noted under phosphorus manuring (Rege and Sannabhadti, 1943). To what extent such variations in the mineral content were related to variations in various carbohydrate and nitrogen fractions would be discussed in a separate paper.

Summary

This paper narrates the results of an experimental inquiry into the effects of phosphorus deficiency and of phosphorus fertilization on the carbohydrate fractions of the sugarcane plant (var. Co. 453).

Phosphorus deficiency failed to show any significant variation in the various sugar fractions such as fructose, total reducing sugars and sucrose content. A tendency of slackened accumulation of sucrose and total sugars towards maturity, however, indicated the possible relation between these fractions and, (i) low phosphorylase and invertase activity under deficiency conditions, (ii) utilization of the simpler carbohydrates in the formation and accumulation of amides and other soluble nitrogenous compounds, and (iii) utilization in the formation of organic acids.

With increase in age all sugar fractions attained high values at maturity. Such accumulation of fructose, glucose, total reducing sugars and sucrose appeared to be due to, (i) a continuous process of slow accumulation taking place in the stem at successive stages of the life cycle, and (ii) to the activity of enzymes resulting in the quicker conversion of simple sugars into sucrose.

The rapid accumulation of sucrose and other fractions in stem indicated that stem acted as a sink from the very beginning of the life cycle where the simple labile sugars coming down from the leaf through the phloem tissue were temporarily converted into complex sugars and stored.

REFERENCES

A.O.A.C. (1945). Methods of Analysis, 3rd. edition.

Eaton, S. V. (1949). Effects of phosphorus deficiency on growth and metabolism of sunflower. *Bot. Gaz.*, **110**: 449-64.

———— (1950). Effect of phosphorus deficiency on growth and metabolism of soyabean. *Ibid.*, **111**: 426-36.

———— (1952). Effects of phosphorus deficiency on growth and metabolism of black mustard. *Ibid.*, **113**: 301-09.

Hartt, C. E. (1935). Studies on enzyme action in sugarcane. I. The characteristics of enzymes and their importance in growth and nutrition of plants. *Haw. Planters' Rec.*, **39**: 171-79.

———— (1943). The synthesis of sucrose in sugarcane plant. II. The effect of specific inhibition upon the interconversion of glucose and fructose and the formation of sucrose in the detached organs of sugarcane plant. *Ibid.*, **47**: 155-70.

Lal, K. N. and Singh, J. N. (1958). Effect of Phosphorus deficiency on various nitrogen fractions of sugarcane. *Ind. Jour. of Sug. cane Research and Dev.*, **II**, 3: 151-60.

Loomis, W. C. and Shull, C. A. (1937). Methods in plant physiology. McGraw-Hill Book Co., Inc., New York.

Mason, T. G. and Maskell, E. J. (1928). (a) Studies on the transport of carbohydrates in the cotton plant. I. A study of diurnal variation in the carbohydrates of leaf, bark and wood, and of the effects of ringing. *Ann. Bot.*, **42**: 189-253.

———— ———— (1928). (b) Studies on the transport of carbohydrates in the cotton plant. II. The factors determining the rate and the direction of movement of sugars. *Ibid.*, **42**: 571-636.

Rege, R. D. and Sannabhadti, S. K. (1943). Problem of sugarcane physiology on the Deccan Canal Tract. IV. Mineral nutrition. (A) phosphates. *Ind. Jour. Agr. Sci.*, **13**: 87-111.

Singh, J. N. (1955). Physiological studies in the phosphorus nutrition of sugarcane. Ph.D. Thesis of Banaras Hindu University.

STUDIES ON PHYSIOLOGICAL BASIS OF DROUGHT RESISTANCE IN SUGARCANE

By

HARDYAL SINGH GILL and HARBANS SINGH

(Sugarcane Research Station, Jullundur, Punjab)

INTRODUCTION

DROUGHT resistance of any type of plants or species of the same plant has been ascribed to a multiplicity of morphological, physiolcgical and physico-chemical characteristics. Testing of varieties for drought resistance had recently attracted considerable attention of the breeders and physiologists in almost all the countries. Breeding of varieties of cereals and other crops resistant to drought, however, received little attention from scientists except in Russia where it attained special importance after the historic drought of 1921 resulting in a national calamity. While sufficient work has been reported on wheat, sorghum, millets etc. such studies on sugarcane do not seem to have received the desired attention so far.

The present investigations reported in this paper formed a part of the work of a field-scale experiment in which six sugarcane varieties were tested under very adverse conditions of irrigations during hot weather. The morphological, physiological and anatomical characteristics of different varieties were studied to see if any relationship existed in these characters and the capacity of a variety to withstand drought conditions.

REVIEW OF LITERATURE

The lack of any of the plant nutrients or soil moisture manifests itself in the changed morphological and other characters of the plants. In order to see what particular plant characteristics are affected by the lack of soil moisture, various workers have conducted investigations in different parts of the world.

Briggs and Shantz (1912 and 1917) and Shantz and Piemeisel (1927) worked on the water requirements of millets, sorghum, rice, buckwheat and certain grasses. Varieties of the same crop showed measurable differences in their water requirements and the authors expressed the possibility of developing strains more efficient in the use of water than those then grown in dry land regions. Tumanov (1927 and 1929) working with alfalfa, oats, corn and sorghum took per cent plant survival as an index of drought resistance. According to him the percentage of dead leaves could not be relied upon as a measure of drought resistance. Kondo (1931) took percentage of dead leaves and fall in grain yield as Criteria of resistance to drought. Papadakis (1933) working on wheat plants found the yield and kernel weight in pot experiments to be fairly indicative of the resistivity of the different species and the results were found in general agreement with observations in the field. According to Nesterova (1935), neither the number of dried up leaves during wilting nor the water content of the plant tissues could give a measure of drought resistance in wheat. The experiments conducted by Udolskaja (1936) were based on the yielding capacities of different varieties of wheat under depleted soil moisture conditions and this formed the basis of evaluating comparative drought resistance.

Khanna and Raheja (1938) while studying the respiratory function of about a dozen sugarcane varieties under the stress of hot weather, observed a fair degree of correlation between the extent of depression in the rate of respiration and the comparative drought resistance of cane varieties. Varieties showing slow and slight deviations from the normal respiratory function were found to be resistant to drought. Lal and Mehrotra (1949) studying the cell size characteristics of 12 sugarcane varieties in relation to drought concluded that the cell indices number was inversely related to the drought enduring capacity of a variety.

MATERIAL AND METHOD

The experiment where these varieties were sown and studied had the following treatments:—

Irrigations		*Varieties*
I_0—No irrigation	×	V1—Co. 312
I_1—One irrigation in hot wheather		V2—Co. 285
		V3—Co. L. 29
I_2—Three irrigations -do-		V4—Co. L. 9
I_3—Five irrigations -do-		V5—Co. 313
		V6—Co. 453

The layout was split plot design with irrigations as main plots and the 24 treatments were replicated four times. In addition to the above irrigations, one common irrigation to start with was applied to all the plots in order to enable the plants to get firmly established before the differential treatments were resorted to. The experiment had a run for two years, 1953-55.

For stomatal and other anatomical studies, the last opened leaf from the primary shoot free from the attack of borers etc. and almost of the same age, was taken from each of these varieties. The leaf samples were clipped with scissors from the plant and kept in water in the laboratory with their cut ends dipped in water. About two inches leaf blade was taken from the portion mid-way between the apex and the base and the midrib and the margin. The peelings, thus, removed from this portion were preserved in five per cent solution of Formalin. The methods followed by Smith (1943) and Lal (1949) were utilised in the selection of material for these studies. Stomatal frequency was determined both on the upper and lower leaf surfaces while their size and cuticle deposition were studied only on the lower epidermis. The studies on anatomy of roots relate to the entire root section as also a unit area under high power.

The morphological and physiological characters taken for study in these investigations are mentioned in the pages to follow.

Ionizable salts in the leaf and stem sap were determined by conductivity method using Philoscope for the purpose.

Experimental Results

(a) *Cell-size characteristics.*—The cell-size characteristic viz. stomatal frequency per unit area, their dimensions, cuticle deposition etc. were worked out for different varieties.

TABLE I

Variety	Year	No. of stomata per sq. mm.		Stomatal frequency ratio of upper to lower surface	Length of stoma in U.	Width of stoma in U.	Ratio of width to length	Total leaf area per plant in sq. cms.	Cuticle deposition in U (lower epidermis)
		Upper epidermis	Lower epidermis						
Co. 312	1953–54	82·1	144·8	0·567	19·12	10·50	1 : 1·821	279·8	6·12
	1954–55	78·9	159·0	0·495	20·14	10·80	1 : 1·865	235·8	7·38
Co. 285	1953–54	112·1	174·0	0·644	21·16	10·96	1 : 1·931	250·3	5·21
	1954–55	92·9	169·4	0·548	20·50	10·80	1 : 1·880	217·4	5·38
Co. L. 29 ..	1953–54	103·0	158·8	0·649	21·16	11·18	1 : 1·892	354·2	4·50
	1954–55	94·8	180·0	0·527	20·70	10·85	1 : 1·908	315·2	4·50
Co. L. 9 ..	1953–54	91·2	163·2	0·558	24·00	12·20	1 : 1·967	216·4	4·12
	1954–55	94·6	183·3	0·516	23·80	12·37	1 : 1·924	220·7	4·26
Co. 313	1953–54	117·2	172·4	0·679	24·00	13·20	1 : 1·818	304·2	3·26
	1954–55	111·3	203.9	0·545	22·20	10·70	1 : 2·075	334·4	3·42
Co. 453	1953–54	127·2	185·0	0·688	26·00	13·28	1 : 1·958	435·6	3·66
	1954–55	118·0	204·2	0·578	26·66	12·55	1 : 1·120	460·3	3·34

The stomatal density as also the ratio of the stomata on the upper surface to lower leaf surface was markedly higher in the case of Co. 453 and Co. 313. On the other hand, these studies revealed comparatively smaller sized stomata both in length and width in the case of Co. 312 as compared to the varieties mentioned above. The other varieties occupied intermediary positions in this respect.

The cuticlė deposition on the lower leaf surface was more in the case of Co. 312 and less in the other two varieties viz. Co. 453 and Co. 313, forming a distinctly separate group. Co. 285, Co. L. 29 and Co. L. 9 occupied intermediary position with regard to number and size of stomata and the cuticle deposition recorded in the case of the above varieties. Co. 285 showed a fairly high ratio of stomatal frequency on the upper

to the lower leaf surface but it differed from Co. 453 and Co. 313 in having a greater deposition of cuticle like Co. 312 on its lower surface.

In the matter of yield (Appendix I), Co. 312 produced significantly higher tonnage in both the years of experimentation under highly restricted irrigations than that recorded in the case of Co. 313 and Co. 453. The other varieties occupied intermediary positions in this respect as well.

The behaviour of Co. 312 to withstand droughty conditions than the other varieties can thus be ascribed to less transpiration due to the presence of small sized stomata, lower ratio in their number on upper and lower surfaces and greater cuticle deposition.

(b) *Vascular bundles in roots.*—As mentioned under ' MATERIAL AND METHOD ', the root samples for these studies were taken from the I_0 irrigational treatment.

TABLE II

Variety	Year	Total number of vascular bundles per root (cross section)	No. of vascular bundles per sq. mm. (roots) (cross section)	Size of the conducting vessel in U. (Cross section)	
				Length	Breadth
Co. 312	1953–54	12·2	19·7	60·00	47·20
	1954–55	13·0	19·8	62·20	45·40
Co. 285	1953–54	12·4	20·4	75·80	61·00
	1954–55	13·5	20·6	73·30	56·60
Co. L. 29	1953–54	10·6	19·1	52·20	45·40
	1954–55	11·2	19·0	50·80	44·60
Co. L. 9	1953–54	10·7	18·9	56·75	45·75
	1954–55	11·0	17·9	54·88	46·40
Co. 313	1953–54	9·6	19·1	55·80	48·00
	1954–55	10·0	18·7	56·00	46·40
Co. 453	1953–54	9·0	17·5	56·16	47·38
	1954–55	9·0	16·8	56·80	48·40

Both number as well the size of these conducting vessels were markedly less in Co. 453 and Co. 313 as compared to Co. 312 and Co. 285. The former two varieties were, therfore, at a disadvantage as compared to the latter two varieties in the matter of free and quick movement of water due to these differences in the anatomy of their roots.

(c) *Root penetration.*—These studies were also carried out in the I_0 treatment. The root dissections were made ' in situ ' in June during both the years (Table III).

Co. 285 and Co. 312 showed the maximum vertical penetration of roots and such penetration was least in the case of Co. 313 and Co. 453. The ratio between the dry weight of roots and the total leaf area per plant was the highest in case of Co. 453 and Co. 313 indicating less water pumping mechanism compared to their transpiring surface.

(d) *Moisture in stem and leaves.*—Samples for these studies were taken in the first week of June. For comparative purposes, these samples were also taken both from I_0 and I_3 irrigational treatments (Table IV).

The per cent moisture was higher in the stem than that in the leaves. Similarly, plants growing under higher levels of irrigation (I_3 treatment) showed greater moisture in their tissues as compared to that under highly restricted irrigations (I_0). While this trend was common in almost all the varieties, considerable variation in moisture contents of the plant tissues were recorded in the case of different varieties under I_0 and I_3 treatments. Co. 312 showed the least variations in the stem and leaf moisture contents under I_0 and I_3 treatments. Compared to other varieties, especially Co. 453 and Co. 313, variety Co. 312 showed the highest per cent moisture in stem and leaves under I_0 treatment. Evidently, aided by the anatomical characteristics, Co. 312 was able to maintain a comparatively higher moisture balance in its tissues for the normal metabolic activities even under highly adverse conditions.

TABLE III

Variety	Year	Total No. of plants in the plot Size (12′×46″) Size	Leaf area per main shoot (sq. cms.)	Max. vertical penetration of roots (cms.)	Dry wt. of roots in gms.	Ratio of dry wt. of roots to total leaf area
Co. 312	1953–54	..	275	62	3·5	1 : 78·6
	1954–55	814	259	74	3·7	1 : 70·0
Co. 285	1953–54	..	147	66	2·7	1 : 54·4
	1954–55	819	181	80	2·8	1 : 66·4
Co. L. 29	1953–54	..	206	56	2·8	1 : 73·5
	1954–55	830	204	65	2·4	1 : 85·0
Co. L. 9	1953–54	..	190	52	2·5	1 : 76·0
	1954–55	694	175	67	2·7	1 : 64·8
Co. 313	1953–54	..	318	52	3·0	1 : 106·0
	1954–55	489	258	51	2·2	1 : 117·3
Co. 453	1953–54	..	452	51	3·3	1 : 167·9
	1954–55	524	355	56	3·0	1 : 131·7

TABLE IV

Variety	1953–54			1954–55		
	I_3	I_o	Difference	I_3	I_o	Difference
			(a) *Leaf*			
Co. 312 ..	71·4	69·6	1·8	70·6	69·4	1·2
Co. 285 ..	69·8	65·0	3·9	68·0	67·6	1·4
Co. L. 29 ..	69·8	66·8	3·0	70·0	66·0	4·0
Co. L. 9 ..	73·0	67·8	5·2	72·8	67·8	5·0
Co. 313 ..	69·7	66·0	3·7	68·8	65·0	3·8
Co. 453 ..	73·8	67·2	6·6	72·0	64·6	7·4
			(b) *Stem*			
Co. 312 ..	82·6	81·2	1·4	81·4	80·2	1·2
Co. 285 ..	83·0	79·8	3·2	82·8	80·0	2·8
Co. L. 29 ..	83·2	79·0	4·2	80·4	77·2	3·2
Co. L. 9 ..	84·8	78·6	6·2	83·0	79·6	3·4
Co. 313 ..	84·7	79·0	5·7	79·6	76·2	3·4
Co. 453 ..	85·6	78·5	7·1	84·2	78·0	6·2

(e) *Percentage of dead leaves.*—As the plant grows, the lower leaves dry up and cease to function. Of the total foliage, i.e. green plus dead leaves, the percentage of dead leaves was worked out in about the close of May and middle of June.

TABLE V

Variety	Year	Percentage of dead leaves				Mean
		I_0	I_1	I_2	I_3	
(a) *End May*						
Co. 312 ..	1953–54	23·4	21·6	11·9	9·3	16·6
	1954–55	30·4	31·9	24·0	10·9	24·3
Co. 285 ..	1953–54	28·8	24·3	18·7	18·3	22·5
	1954–55	34·7	34·8	28·2	14.3	28·0
Co. L. 29 ..	1953–54	25·0	22·9	10·9	9·5	17·1
	1954–55	34·7	34·8	22·1	12.0	25·9
Co. L. 9 ..	1953–54	24·6	22·1	20·0	16·4	20·8
	1954–55	33·8	35·5	24·3	12·8	26·6
Co. 313 ..	1953–54	26·1	22·1	18·6	13·3	20·0
	1954–55	39·4	42·2	26·0	14·1	30·4
Co. 453 ..	1953–54	30·4	29·0	21·4	22·5	25·8
	1954–55	43·1	43·9	33·8	19·5	35·1
Mean ..	1953–54	26·4	23·7	16·9	14·9	..
	1954–55	36·0	37·2	26·4	13·9	..
(b) *Mid-June*						
Co. 312 ..	1953–54	30·5	23·7	19·4	22·3	24·0
	1954–55	25·5	24·7	18·4	16·5	21·3
Co. 285 ..	1953–54	34·9	26·2	20·8	25·0	26·7
	1954–55	32·6	28·7	22·2	21·4	26·2
Co. L. 29 ..	1953–54	30·4	21·1	18·6	18·2	22·1
	1954–55	33·3	26·0	21·9	13·7	23·7
Co. L. 9 ..	1953–54	30·9	26·1	20·0	23·1	25·0
	1954–55	29·2	27·5	21·6	20·2	24·6
Co. 313 ..	1953–54	34·9	27·0	22·1	22·3	26·6
	1954–55	37·1	32·6	23·9	23·0	29·2
Co. 453 ..	1953–54	34·6	26·4	24·7	26·0	27·9
	1954–55	36·0	30·3	25·3	17·9	27·4
Mean ..	1953–54	32·7	25·1	20·9	22·8	..
	1954–55	32·3	28·3	22·2	18·8	..

The observations regarding per cent dead leaf figures recorded under I_0 treatment about the end of May when subjected to statistical analysis placed the varieties in the following order.

There were distinct differences in the figures of per cent dead leaves in case of different varieties. It was lowest in Co. 312 and highest in Co. 313 and Co. 453 especially during 1954-55 when the weather conditions (Appendix II) were also very unfavourable. Thus, due probably to its special mechanism

to cut down transpiration, Co. 312 was able to maintain higher percentage of green leaves under adverse conditions. Its better metabolic activities under I_0 as compared to other varieties are attributable to its capacity to maintain a higher percentage of green leaves.

Conclusions at 5 percent:— C.D. at 5%

1953–54 ..	Co. 453 29·24	Co. 285 26·40	Co. L. 9 24·79	Co. L. 29 24·21	Co .313 24·10	Co. 312 22·34	3·21
1954–55 ..	Co. 453 43·49	Co. 313 40·33	Co. 285 34·68	Co. L. 29 34·50	Co. L. 9 34·49	Co. 312 29·85	4·45

(f) *Total ionizable salts.*—The leaf and stem samples taken for cell sap extraction in the case of these studies were taken in June during the pre-monsoon period.

TABLE VI

Variety	Percentage of total ionizable salts			
	June 1953		June 1954	
	Leaves	Stem	Leaves	Stem
Co. 312 ..	1·612	1·420	1·705	1·530
Co. 285 ..	1·753	1·491	1·809	1·473
Co. L. 29 ..	1·705	1·569	1·612	1·614
Co. L. 9 ..	1·809	1·550	1·612	1·283
Co. 313 ..	1·110	1·569	2·307	1·491
Co. 453 ..	1·981	1·655	1·899	1·682

Co. 312 showed a lower percentage of ionizable salts both in leaf and stem sap as compared to Co. 453 and Co. 313. Their presence in the case of other varieties (Co. 285, Co. L. 29 and Co. L. 9) did not show consistency during the two years of study nor any relationship to be indicated between this character and the behaviour of these varieties in the matter of their yielding capacity under restricted irrigations.

DISCUSSION

Co. 312 showed a much better performance than other varieties under study in regard to growth and final yield under droughty conditions created due to highly restricted irrigations in hot weather. Its anatomical examination showed lesser number of stomata both on upper and lower leaf surfaces, narrow ratio in their number on the two sides, smaller size, greater cuticle deposition and higher number and size of vascular bundles in roots. Mameli Calvino (1926), Lal and Mehrotra (1949), Rao (1950) and Ikehata Yusaku (1952) in their studies also recorded these xerophytic characters in the varieties able to withstand drought conditions better than others. The better growth and yield performance of Co. 312 in these studies indicated its greater drought resistance and the presence of xerophytic characters in the same variety establishes a positive association between these characters and the capacity of a variety to withstand drought.

In these studies, the greater vertical root penetration, and narrow ratio between the dry weight of roots to total foliar expansion observed in the case of Co. 312 are the other characters related to drought resistance in cane varieties. These observations are corroborated by Miller (1916), Ivanov (1939) and Pohjakalio (1943).

The higher number of Vascular bundles in the roots of Co. 312 also appears to be an important character connected with the xerophytic nature of this variety. The higher per cent moisture in foliage and stem under restricted irrigations and lower percentage of dead leaves to total leaves (green plus dead) are the other characters revealed by these studies to have added to the drought resistance character of Co. 312. Kondo (1931) also in his studies recorded a fall in grain yield to be positively associated with the higher percentage of dead leaves. According to him, per cent dead leaves forms an important criterion of drought

resistance in the wheat varieties. These observations are in conformity with those described in this paper. The resistant variety (Co. 312) showed less percentage of dead leaves.

The different anatomical, morphological and physiological characters described in this paper can, with advantage, be employed in the preliminary classification of cane varieties in assessing their capacity to stand drought.

Summary

1. Six important varieties viz. Co. 312, Co. 285, Co. L. 29, Co. L. 9, Co. 313 and Co. 453 were tried in a field experiment under different irrigation levels during hot weather at the Sugarcane Research Station, Jullundur, for assessing their yield potentials. These varieties were also taken for the study of anatomical, morphological and physiological characters to see if any relationship exists between these characters and the capacity of different varieties to stand droughty conditions. The studies continued for two years.

2. Both density and stomatal ratio (upper to lower leaf surface) was less in the case of Co. 312 as compared to that recorded in Co. 453 and Co. 313. The size of the stomata was smaller but the cuticle deposition greater in the case of Co. 312.

3. Co. 312 also showed greater number and size of vascular bundles in the roots, narrow ratio of dry weight of roots to total leaf surface and deeper vertical penetration of its roots as compared to other varieties, especially Co. 313 and Co. 453.

4. The per cent moisture studies on foliage and stem from two irrigational treatments i.e. highly restricted and higher irrigations also brought less variation in this attribute in the case of Co. 312 under restricted and higher irrigations, whereas other varieties especially Co. 313 and Co. 453 showed wide variation in this respect.

5. Co. 312 showed low per cent dead leaves to the total foliage (green plus dead) even under restricted irrigations compared to other varieties.

6. The total ionizable salts in the sap of leaves as well as stem were also low in the case of Co. 312 as compared to Co. 453 and Co. 313 during both the years. These salts, however, did not show any consistency in the case of other varieties.

7. Co. 312 in the two years of these studies gave an average yield of 605·89 maunds per acre under highly restricted irrigations where only one irrigation of 3 acre inches was given throughout the life of the crop. Co. 313 and Co. 453 gave 203·47 and 409·86 maunds yield, respectively under the same treatment. The yield of the other varieties was, Co. 285 (431·90 mds.), Co. L. 29 (393·65 mds.), and Co. L. 9 (466·17 mds.), Co. 312, thus, proved to be a drought-resistant variety.

8. The xerophytic nature of Co. 312 is evidently the resultant of the anatomical and physiological characters observed in this variety. These characters, having close association with the capacity of a variety to stand water shortage, can, with advantage, be employed in the preliminary classification of varieties in assessing their drought resistance.

Acknowledgments

Grateful thanks are due to the Indian Central Sugarcane Committee for financing the Sugarcane Research Scheme under which these studies were carried out.

REFERENCES

Briggs, L. J., Shantz, H. L. (1912). The relative wilting Co-efficients for different plants. *Bot. Gaz.*, **53**: 229-35.

——— (1917). The water requirements of plants as influenced by environments. *Proc. Sec. Pan. Amer. Sci. Cong.*

Ikehata, Yusaku (1952). Studies on drought resistance of Sugarcane. (*Biol. Abst. Vol.*, **27**(3), 32-865, 1953).

Ivanov, P. K. (1939). The root system and drought resistance of different varieties of wheat (Quoted from V. S. Mani, postgraduate thesis, I.A.R.I.).

Khanna, K. L., and Raheja, P. C. (1938). Water requirements of sugarcane varieties during hot weather. *Proc. 20th, Ind. Sci. Cong.*

Kondo, J. N. (1931). The influence of external factors as well stages of development on the resistance of plants to dehydration *Bull. Appl. Bot. Genet. & Pl. Breed.*, **27**: 129-56. (*Canad. Jour. Res.*, **14C**: 122-52, 1936).

Lal, K. N. and Mehrotra, O. N. (1949). Studies in Crop Physiology; Cell size characteristics of sugarcane varieties in relation to drought resistance. *Bot. Gaz.*, **111**(2): 193-210.

Mameli Calvino, E. (1926). Xerophytic characters of sugarcane (*Biol. Abst.*, **2**: 18884, 1928).

Nesterova, E. I. (1935). Resistance to soil drought in certain varieties of spring wheat. (*Pl. Breed. Abstr.*, **6**: 1196).

Pohjakalio, O. (1942). Unter suchungen uber died Trockenperiode (quoted from *Pl. Breed. Abstr.*, **19**(1): 321, 1949).

Papadakis, J. S. (1933). Method of evaluation of drought resistance. *Sci. Bull. Inst. Pl. Breed. Salonica* No. **13**: 20.

Rao, J. T. (1950). Xeromorphic adaptation in sugarcane for resistance to drought. *Int. Soc. Sug. Tech. 7th Cong.*, Brisbane.

Smith, H. E. (1943). Polyploidy in sedum pulchellume II. Stomatal size and frequency. *Bull. Torrey Bot. Club*, **70** : 261-264, 1943.

Shantz, H. L. and Piemeisel, R. L. (1927). The water requirements of plants at Akron Colorado. *Jour. Agric. Res.*, **34**: 1093-1190.

Tumanov, J. J. (1927 and 1929). Wilting and drought resistance. *Cand. J. Res.*, **14c**: 122-52.

Ud Iskaja, N. L. (1936). Drought resistance of spring wheat varieties (*Pl. Breed. Abstr.*, **9**: 206).

Appendix I

Variety	Year	Cane yield in mds. per acre				Mean
		I_0	I_1	I_2	I_3	
Co. 312 ..	1953–54	592·34	707·63	675·75	802·19	694·48
	1954–55	619·44	501·50	695·94	706·03	630·73
Co. 285 ..	1953–54	420·22	513·19	536·56	622·63	523·15
	1954–55	443.59	383·56	553·03	622·09	500·57
*Co. L. 29 ..	1953–54	486·63	582·32	576·94	657·16	575·75
	1954–55	300·69	446·78	327·25	525·94	400·17
Co. L. 9 ..	1953–54	445·19	506·28	510·00	600·31	515·45
	1954–55	487·16	425·53	548·25	602·97	515·98
Co. 313 ..	1953–54	249·16	459·53	389·41	578·00	419·03
	1954–55	157·78	172·13	240·13	275·19	211·31
Co. 453 ..	1953–54	413·84	584·91	542·41	706·03	561·80
	1954–55	405·88	489·28	527·00	533·91	489·02
Mean ..	1953–54	434·56	558·97	538·58	661·05	..
	1954–55	402·43	403·13	481·93	544·36	..

*The behaviour of this variety during 1954–55 was not a normal one, as a large number of plants died due to an unknown cause. The mortality of plants in this variety was not noticed in the preceding year either at the farm or in this trial.

Appendix II

Months	Year	Temperature ° F. Maximum		Temperature ° F. Minimum		Soil temperature ° F. (30 cm. depth)		Humidity percentage		Rainfall in inches
		Highest	Mean	Lowest	Mean	0728 hrs.	1428 hrs.	0728 hrs.	1428 hrs.	
March ..	1953	95·2	89·7	49·5	57·0	73·5	73·5	80	25	T
	1954	94·1	80·4	39·5	53·3	65·8	67·2	86	38	3·26
April ..	1953	107·1	96·3	52·3	64·0	80·9	81·2	58	22	0·58
	1954	104·6	96·3	54·4	62·7	81·2	83·4	58	19	0·02
May ..	1953	111·0	104·7	68·1	75·8	91·0	91·3	46	21	0·19
	1954	113·5	106·6	63·1	72·9	91·7	94·9	40	17	0·23
June ..	1953	114·0	103·8	71·6	80·5	94·9	95·3	55	35	0·35
	1954	114·4	105·9	69·6	81·8	97·9	100·6	50	27	0·39
July ..	1953	105·0	93·6	72·2	79·7	89·5	89·8	87	70	17·81
	1954	107·5	96·1	72·5	78·8	93·5	95·4	79	56	4·39
August ..	1953	100·1	92·7	72·4	78·5	88·5	89·4	87	65	4·59
	1954	104·3	98·8	73·0	79·8	96·8	98·6	77	50	1·32
September	1953	99·1	94·6	65·0	73·8	87·9	89·2	85	49	2·21
	1954	102·6	91·9	70·5	75·9	87·8	89·1	88	66	11·38
October ..	1953	99·6	92·9	48·2	60·0	82·4	83·1	77	25	T
	1954	91·9	86·2	51·2	57·2	77·4	78·2	87	37	1·13
November	1953	90·3	82·3	39·4	40·1	70·5	70·8	88	24	T
	1954	85·1	83·0	40·6	40·8	69·3	70·0	86	30	T
December	1953	81·7	75·7	40·7	44·9	63·7	63·6	91	40	0·77
	1954	79·8	71·4	31·6	38·8	59·9	60·1	88	34	0·00
January ..	1954	74·0	63·8	31·9	40·6	54·9	55·2	92	53	0·83
	1955	73·6	66·1	28·4	41·0	56·2	56·5	92	49	1·51
February	1954	76·5	69·0	43·6	51·6	59·2	60·2	93	63	5·47
	1955	87·0	74·8	35·2	41·5	59·4	59·8	89	33	0·02

T denotes traces of rainfall.

Total rainfall:—

1953–54 = 32·80 inches

1954–55 = 23·65 „

STUDIES IN GERMINATION OF SUGARCANE—THE QUESTION OF AUXIN RELATIONSHIP, POLARITY, POSITION OF THE BUD IN THE SOIL AND INTERNODAL LENGTH AS INFLUENCING IT

By

M. S. Subha Rao,* R. B. Prasad and K. L. Khanna

(Sugarcane Research Institute, Pusa, Bihar)

Introduction

Enhanced rate and extent of germination is the first requirement in successful crop production. This question is more accentuated in a vegetatively propagated crop like sugarcane. Incomplete germination brings about in its wake wide gaps in the field with resultant low density of crop stand and yield. This phase of sugarcane culture has, therefore, attracted the attention of research workers for a long time. Research work aiming to unfold causes for failure of germination and to improve the same has progressed along definite lines, the more important of which are: (a) Pre-soaking treatments of sugarcane setts, (b) auxin relationship and polarity of buds in the sugarcane sett and (c) creation of conditions ideal for the buds to germinate when placed in soil with special reference to position of the bud and its nutrient reserve.

The earlier attempts of pre-soaking setts in water (1, 2, 3, 4, 5)† or solutions of various chemicals e.g., micro-elements (4, 6, 7), lime wash (8, 9, 10), potassium permangate, potassium ferricynide, Ammonium Sulphate (4) and saturated lime solution mixed with magnesium sulphate (11) and had the basic idea of improving the glucose content (12), amino-nitrogen (19) and general metabolic activity (13) which were thought to determine germinability of setts. Soaking in water alone for varying durations was found useful wherever moisture was the limiting factor in the soil or sett. Top immature portion of cane, providing nutrients in the degraded utilisable form, has been on this score recommended as ideal planting material. The usual trend of pre-soaking treatment given to the sett for ideal germination has been, however, reoriented on the basis of recent researches in that the failure of germination has been attributed to the ingress of soil micro-flora through the cut ends (14, 15) and the resultant incomplete fermentation, the products of which become toxic to the growing seedling. In recognition of this, coating of cut ends with mercuric salts has improved germination phenomenally. Proprietary products like Aretan and Agallol have been able to give very much enhanced germination and their use has been widely in vogue in recent years (16, 17).

The impress of apical dominance in the entire cane as well as in each section of the cut cane carrying more than one bud has been recognised for a long time (18, 32). On the basis of researches with setts containing more than one bud, it has been concluded that 3-budded setts are the most economic and ideal ones to build up a good stand of cane (20, 21, 22, 23). The scientific basis of the question of apical dominance appears to be that a bud germinates only when its auxin content is reduced below a critical level by pumping it downwards along the gradient. In this way the natural auxin is pumped from the topmost bud to the next to keep that in check so long as that itself does not germinate. This phenomenon continues from one bud to the next, the bud that is about to germinate affecting in its turn the one immediately after it. In a 3-budded sett, the same phenomenon occurs in that the topmost bud keeps in check the 2nd and this in its turn the 3rd.

Recent researches have corroborated the above findings in that the treatments bringing about lessening of auxin or its disintegration have enhanced the extent of germination (24). Hot water treatment given to the sett as a protective measure against bacterial diseases has enhanced germination even under conditions where bacterial diseases were non-existent. Assay of auxins in the treated and untreated setts depicted lower auxin content in the treated setts pointing to the fact that disintegration of auxin enhanced germination (25). Researches on the interval between harvest and planting of cane for high germinability showed an interval of 3 to 4 days to be ideal under the conditions of Louisiana (U.S.A.). Auxin analysis also showed the same trend where it touched a minimum when the response to germination was highest (26).

---

* At present Crop. Physiologist, Bihar, Ranchi.

† These Numbers refer to the list of literature cited

The above two facts go to prove that auxin and its disintegration have a major role in improving germination. It is difficult to say how far it is interlinked with the question of neutralising apical dominance completely so that polarity does not come into operation under actual conditions of germination.

The position of the bud in the soil has also attracted attention of workers. Martin (27) observed that 'Up' buds germinate first while the 'down' buds require twice the time according to the greater distance their shoots have to traverse to reach the surface. Results in Uttar Pradesh have shown greater germination for 'Up' buds and lowest for 'down' buds while side buds stood intermediate in performance (28). Further, Gahlot working on 3-budded setts found that setts with all 3-buds on 'sides' and setts with two buds 'Up' and one bud 'down' gave almost similar germination percentage, but much higher than the setts with two buds 'down' and one 'Up' (29). How far the position of bud alone would affect the germinability in the light of the pre-treatment given to the sett on the lines suggested above needs further elucidation. Linked up with this is the question of the amount of nutrients available to the growing bud viz:- the quantity of internodal tissue also needs consideration. Venkataraman, as early as in 1926, pointed out that it was not only the number of buds, but also the amount of internodal tissue or the length of internode that was concerned—the longer the internode, the larger the amount of nutrients available to the growing bud. He actually demonstrated the beneficial effect of long internodes connected with the bud for better germination (30). Keeping in view all these newer trends on germination, it would be interesting to assess whether varieties with longer internodes are better off from the point of view of germination.

Against this background, an experiment was planned to ascertain the extent to which top-dominance and position of bud in soil are responsible for germination. The question of neutralising the natural auxin effect by soaking in synthetic hormones has also been considered. Side by side with this, the problem of the length of internodes as related to their germination capacities in the different varieties has also been brought in for discussion.

Experimental Methods

Three-budded setts of B.O. 14 variety were soaked for a duration of 15 minutes in a solution of 100 ppm Indole acetic acid and Napthalene acetic acid. A corresponding water treatment was also maintained along with a control where no treatment was given. Treated setts were planted in the usual manner and covered up without any consideration either for the position or the polarity of the buds. When germination was complete, the setts were very carefully uncovered by removing the soil on all the sides and the polarity of the buds and its position in the soil were noted. The total numbers of buds germinated and the number of buds rotted under each category—top, middle and bottom were noted. The numbers of tillers already emerged under the same category were also counted for the different treatments. All these data were assessed in terms of the percentage of buds planted to analyse the value of the different treatments, by subjecting it to statistical analysis. Data were also tabulated in relation to each treatment on the position of the bud and percentage of the buds germinated in each position. Conclusions drawn on the basis of the above treatments have been discussed below.

Experimental Findings and Discussions

Differences between the various treatments viz., soaking in NAA, IAA, water and direct planting were non-significant in that soaking in these hormones did not bring about any antidoting effect of the natural hormones. Khan and Hall (31) working with two varieties and two hormones viz., IAA and alpha O-OCPA also did not find any improvement in germination when soaked in solutions; on the other hand they found an improved germination when they were mixed in 1:9 ratio, pointing out to possible interaction of one type of growth regulator with another and to an antagonistic effect which is known in a number of synthetic auxins. Soaking in water being too short (C.P.11) the setts were probably unable to absorb water or leach out auxins (C.P. 31) during the treatment and bring about its impress.

The differences under the three categories (top, middle and bottom) on the average, were significant in respect of germination percentage, it being highest with the middle bud and lowest with the bottom bud (Table I).

With the available data supporting the view that the top bud was the most responsive from the point of view of germination, the result obtained under the experimental conditions needs thorough evaluation. Khan and Hall (31) have pointed out stalk position effect where the middle portions of the stalk were found to respond best in germination as well as root development. Causes for the high response of germination with the middle bud pointed to the probability of higher availability of nutrients with the greater internodal tissue attached to the middle bud as compared to end buds, with varying degree of internodal tissue on one side depending upon the position of the given cut. This fact of higher response of a bud with greater internodal tissue was pointed out by a host of workers (27, 30, 33, 34). On the basis of recent

TABLE I

Treatment	Germination (%)			Rotten buds (%)			Mean No. of tillers		
	Top	Middle	Bottom	Top	Middle	Bottom	Top	Middle	Bottom
Control	62·5	70·0	40·0	25·0	20·0	35·0	0·85	0·50	0·31
	57·4*	56·8*	38·2*	..	..	..	..	..	..
Water	48·4	82·5	40·0	15·8	9·1	30·8	1·30	0·50	0·05
	44·0*	65·3*	38·7*	..	..	..	..	..	..
NAA	66·6	66·7	43·3	18·1	13·0	20·4	1·05	1·23	0·13
	49·9*	46·5*	36·2*	..	..	..	..	..	..
IAA	57·5	52·5	35·0	35·0	27·5	37·5	1·23	0·70	0·12
	54·8*	54·8*	41·1*	..	..	..	..	..	..

S.E. (Treat) Mean $\pm 5 \cdot 07$, S.E. (Bud) Mean $\pm 2 \cdot 54$
* Transformed values.

findings, as stated earlier, the question of germination failure is thought of as due to ingress of micro-organisms. If this contention is agreed (which is justified on the basis of the high response obtained by treatment of cut ends), the damage caused would be least to the middle bud, the entry being on either side of the cut ends. This would conserve the middle bud against the initial attack from either side and is likely to bring about sure germination on the part of the middle bud. If this proposition is correct, the germinability in different varieties under normal conditions should roughly correspond to the length of internodes; the longer the internode, greater the germination response. Data collected in a varietal trial on the percentage germination attained and the length of the internode at the pre-harvest stage when correlated appeared to show a straight line of closest fit, but for some negligible inconsistencies (Fig. 1). This again supports the contention that the middle bud with the greater amount of internodal tissue is in a better position to respond to higher germination.

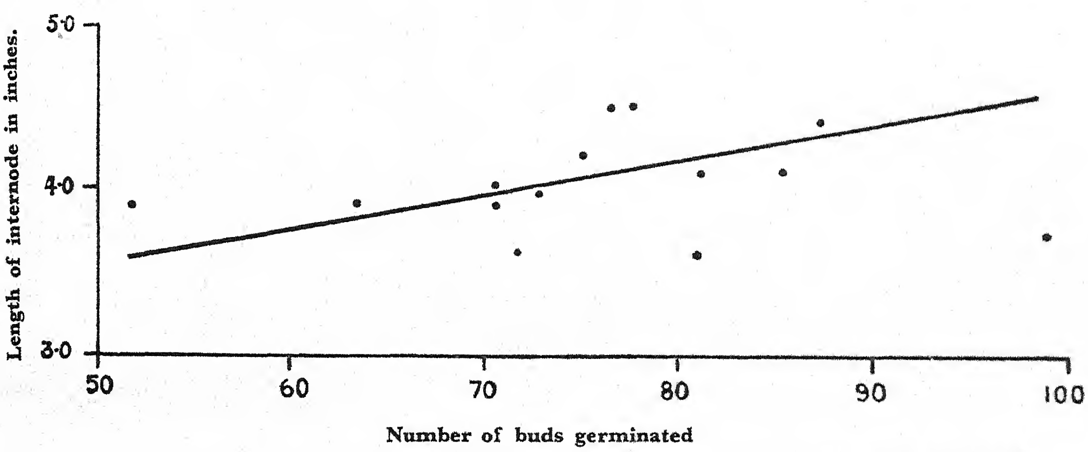


FIG. 1. Showing the direct relationship between length of internode and number of buds germinated.

The response of lowest germination in bottom bud conforms to the findings of earlier workers with the attendant greater impress of the apical dominance phenomenon on it. The bottom bud coming lowest in the rung in order of polarity, is liable to rot with the greater time interval necessary for it to germinate under field conditions providing very poor contribution to the total germination.

As regards the influence of each one of these treatments viz. soaking in water, NAA and IAA, on the differences in germination with respect to top, middle and bottom buds, it was found in case of water soaking that response of middle bud was significantly different from either the top or bottom buds, there being no difference between top and bottom buds—pointing again to the fact that soaking in water for such a

short duration had no effect of any kind. On the other hand, with IAA, differences in germination were non-significant, while in case of NAA and direct planting top as well as middle buds significantly differed from bottom, the differences between top and middle buds being non-significant. These naturally pointed to the differential effects of these two separate groups of auxins—the indole derivative and napthelene derivative. Lack of complete effectiveness of the treatment was again apparent.

So far as the response of germination under the various treatments in relation to position of bud in the soil was concerned, it was evident that irrespective of the treatments, the buds in the above position gave the maximum germination; buds situated on the sides gave the next best germination, with buds situated downwards giving the least response (Table II).

TABLE II

Germination Percentage

Treatments	Position of the bud in the soil		
	Side	Up	Down
Control	40·0	80·5	56·0
Water	54·1	72·3	46·5
NAA	59·4	65·2	45·2
IAA	49·1	54·2	42·2

The chemicals themselves appeared to have no influence on germination with respect to the position of bud. On the basis of practicability, in a three-budded sett, more number of buds could be brought in the lateral position than otherwise. The later would bring about restriction on the number of buds effective. On the basis of the findings of this experiment, evaluation of the buds in different positions, has shown that the position of two buds at 'top' and one 'down' in a three-budded sett has given the highest percentage germination, with all the three buds on the sides giving nearly ten per cent lower germination. On this score it seems more profitable to plant with two buds 'up' and one bud 'down'. This conclusion is, however, at variance with the findings and conclusions of Clements (32) who feels that cuttings with more than one node should be planted with the buds to the sides, as planting the cutting with the buds in a random position is to waste nearly all the buds in the down position. But, the fact remains that the bud which goes down in a three-budded sett is invariably the middle one with greater amount of internodal tissue and away from the cut ends to be so rapidly overcome by the invasion of soil microflora and as such may not be a complete failure as suggested by Clements. Subsequent findings of protection given to the sett by coating of cut ends by organo-mercurial fungicide may do away with the handicap for the bud positioned downward and enable all the three buds to germinate, wherever such pre-planting treatments have been given. Gahlot (29) working under conditions of Uttar Pradesh has found that with two buds 'Up', one down and three buds on the side, plantings have given almost identical germination percentages lending additional support to the findings of the authors. As already indicated, protection to the cut ends is likely to prove better and the position of two buds 'up' and one 'down' may far out-stretch all the other positions in the case of three budded setts.

Number of tillers produced in terms of polarity of the bud (top, middle and bottom) were tabulated at the time of exposure of the setts. Data recorded showed that the top bud which germinated earliest depicted an unmistakable trend of highest mean number of tillers per clump; the bottom bud was most inferior, the middle bud being intermediate in this respect. The higher number of tillers formed with the top bud, and that too formed earliest in the life cycle, is likely to bring about that difference of physiological age as distinct from physical age and help in better and uniform maturity of the stalks to give higher juice quality. Further work on all these lines is in progress.

SUMMARY

In the foregoing pages the results of an investigation carried out on the question of auxin relationship, polarity, position of the bud in the soil and internodal length as influencing germination have been detailed along with a critical review of the recent trends of research.

Soaking of setts in auxins, IAA and NAA, and water as a pre-planting treatment did not influence germination at all, possibly due to non-absorption of the chemicals in the short time provided for soaking.

Of the top, middle and bottom buds of the three budded sett, the middle bud gave the highest germination percentage followed by the top and bottom buds respectively. It is thought that the middle bud being distantly situated from the cut ends is not open to shortage of nutrients and toxicity conditions which the the end buds have to put up with, in the wake of ingress of soil micro-organisms through the cut ends. In this connection the beneficial effect of longer internodes towards better germination has been demonstrated.

Top buds which germinated early produced more number of tillers compared to middle and bottom buds.

As regards position of the buds in soil 'Up' buds gave the highest germination followed by 'side' and 'down' buds in decreasing order. The two buds 'up' and one 'down' (with reference to a three budded sett) position gave about 10 per cent higher germination over the position with all the three buds on sides.

ACKNOWLEDGMENT

Grateful thanks are due to the Government of Bihar and the Indian Central Sugarcane Committee who are jointly financing the Scheme of Sugarcane Research in Bihar under which the present work was done.

REFERENCES

1. Khanna, K. L. (1933). *Ann. Rept. Sug.cane Res. Stat.*
2. Mookerjee, B. K. (1945). *Ann. Rept. Sug.cane Res. Sta.*, Shahjahanpur.
3. Singh, H. (1941). *Ann. Rept. Sug.cane Res. Sta.*, Punjab.
4. Vijayasaradhy, M. *et al.* (1954). *Proc. 2nd. Bien. Conf. Sug.cane Res. Workers*, India.
5. Mathur, R. N. (1940). *Proc. 9th Ann. Cong. Sug. Technol. Assn.*, India.
6. Rege, R. D. (1952). *Ann. Rept. Sug.cane Res. Sta.*, Padegaon, Bombay.
7. Dutt, N. L. (1952). *Ann. Rept. Sug.cane Breeding Instt.*, Coimbatore.
8. Rege, R. D. (1939). *Ann. Rept. Sug.cane Res. Sta.*, Padegaon.
9. Khanna, K. L. (1934). *Ann. Rept. Sug.cane Res. Sta.*, Bihar.
10. Mitra, M. K. (1942). *Ibid.*, Shahjahanpur.
11. Evans, H. (1935). *Revue Agricole* (Mauritius), **14**: 113-14.
12. Singh, *et al.* (1955). *Ind. J. Agric., Sci.*, **5**: 715-28.
13. Khanna, K. L. (1935). *Ann. Rept. Sug.cane Res. Sta.*, Bihar.
14. Mc. Martin, (1945). *Proc. 9th Ann. cont. S. Afr. Technol. Abs.*, **48**: 51.
15. ————, (1946). *S. Afr. Sug. Jour.*, **30**: 71-73.
16. Subba Rao, M. S., Negi, N. S. and Khanna, K. L. (1956). *Curr. Sci.*, **25**: 159-60.
17. Singh, Gill and Singh (1957). *3rd. Bien. Conf. Sug.cane Res. & Dev. Workers*, India.
18. Vaghalkar (1934). *Ann. Rept. Sug.cane Res. Sta.*, Padegaon.
19. ————, (1936). *Ibid.*
20. Mathur, R. N. (1939). *Ann. Rept. Sug.cane Res. Sta.*, Shajahanapur, U.P.
21. Vagholkar (1935). *Ibid.*, Padageon.
22. Singh, H. (1938). *Ibid.*, Risalewala, Punjab.
23. Hussainy (1951). *Proc. 1st Bien. Conf. Sug.cane Res. Workers*, India.
24. Anonym (1944). *Ann. Rep. of the Director of Inst. of Trop. Agric. of Puerto Rico.*, 1943-44.
25. Brandes and Van Overbeek (1948). *Journ. Agri. Res.*, **770**: 223-38.
26. Coleman (1953). *U.S.D.A.*, No. 6, **32**.
27. Moir (1922). *Haw. Plant. Rec.*, **26**: 219-22.
28. Mookerjee, B. K. (1945). *Ann. Rep. Sug. Res. Sta.*, Shahjahanpur.
29. Gahlot (1956). *Indian Sugar*, **6**: 652-71.
30. Venkataraman, T. S. (1926). *Agric. Journ. India*, **21**: 103-106.
31. Khan and Hall, C. (1954). *Bot. Gaz.*, **115**: 261-71.
32. Clements, H. (1940). *Haw. Plan Rec.*, **44**: 117-46.
33. King, N. C. (1934). *Sugar News*, **15**: 315-20.
34. Anonym (1938). *Rept. of Committee incharge of Experiment Stn. Haw. Sug. Plant. Assn.*

MOWHRA CAKE AS A NITROGENOUS FERTILIZER FOR SUGARCANE

By

V. K. LELEY[1] and S. D. AGASHE[2]

(Department of Agriculture, Poona, Bombay)

INTRODUCTION

MOWHRA seeds (*Bassia latifolia*) are available in fairly large quantities in the forests of Central and Western India. They yield a high per cent of oil containing a fair concentration of solid fatty acids. The oil finds extensive use in the soap manufacture. The residual cake left after oil pressing, contains about 3 per cent nitrogen and 0·6 per cent Phosphate (P_2O_5). Annual production of the cake is rapidly increasing as more and more of the oil is consumed in soap manufacture. The cake contains saponins and some other bitter principles. It is not usually used as a cattle feed. As a fertilizer, it has been found to be exceedingly slow acting. Panse (1945) tried it for manuring cotton but concluded that it was not a useful source of nitrogen. It was also tried on paddy at Agricultural Research Station, Padegaon (1952-53) and was found equally unsatisfactory. Hutcheson (1920-21) and Plyman *et al.* (1922) attributed the very low availability of nitrogen from the cake to the almost complete absence of nitrification of the cake in soil. Rege (1925) concluded that the low nitrifiability of the cake was due to the presence of saponins.

In the literature referred to above, the laboratory studies on cake nitrification were of a short duration. Similarly in the field experiments, the crop used had also a comparatively short field life. If the decomposition of the cake is delayed by the presence of saponin as pointed out by Rege (*loc. cit.*), the cake may prove to be a good fertiliser for crops, like sugarcane which remain in field for a sufficiently long time. However two years field data of a feeler experiment on sugarcane (January planting) at the Padegaon Research Station during 1952-53 and 1953-54 were not encouraging. In both years cane yields from the mowhra cake treatments were significantly low. The experiment was further repeated during the third year by taking morphological and biochemical observations to ascertain the exact cause of the low yields. Results of these observations are presented in this paper.

EXPERIMENTAL DETAILS

The experiment was in progress at the Agricultural Research Station, Padegaon from 1952. It consisted of six treatments of different N.T.D.'s. The layout of the experiment was randomised block design with four replicates. Each year, Co. 419 variety of sugarcane was planted in January and harvested after 12 months. The total nitrogen applied in the form of different fertilizer mixtures amounted to 300 lbs. per acre. It was not supplemented with potash or phosphates. Only three treatments from the above experiment were selected for the present study. They comprised following three N.T.D.'S.

1. Mowhra cake.
2. Sulphate of ammonia plus Mowhra cake.
3. Sulphate of ammonia plus Groundnut cake.

In the case of the last two, sulphate of ammonia and cake were mixed in 1:2 nitrogen proportion.

METHOD OF SAMPLING

Preliminary observations regarding the morphological measurements, and nutrient concentrations in the sugarcane tissues indicated that the routine method of sampling based on an average cane was not quite suitable to bring out small differences due to variable availability of nitrogen from the different N.T D'S. In sugarcane, an individual stool forms an internally connected unit and the tendency appears to be to adjust the stool size to suit the nutrient supply (Dillewijn 1952). Consequently the supply position of nutrients can better be represented by the whole stool rather than individual canes. Instead of taking a representative

[1] Dr. V. K. Leley, Assistant Soil Chemist, Scheme for Expanded Soil Testing Service, Poona Centre, College of Agriculture, Poona-5.

[2] Shri S. D. Agashe, Senior Laboratory Assistant to the Agricultural Chemist, Department of Agriculture, Bombay State, Poona-5.

sample of canes a sample of four average stools (one from each replicate) was collected periodically. All millable canes in these stools were mixed and the whole sample was used for morphological observations and for chemical analysis. Due to limitations of number of stools available for sampling these figures could not be statistically examined.

Cane Yields

Average cane yields from the three selected treatments during 1952 to 1955 are given in Table I.

Table I

Yield data of the selected manurial treatments

Treatment	Years 1952–53	1953–54	1954–55
	Tons per acre		
Mowhra cake	8·99	32·75	30·02
Sulphate of Ammonia + Mowhra cake	9·55	47·33*	31·49
Sulphate of Ammonia+Groundnut cake	11·14	52·14*	48·62*
C.D. at 5%	3·798	14·98	3·211

Among the three years, 1952-53 season appears to be abnormal and the cane yields even on the standard N.T.D. of SA + GNC are extremely low. This was partly due to heavy infestation with pests and partly to the scarcity of irrigation. During the next two years the cane yields are normal and the mowhra cake N.T.D. has yielded significantly less cane tonnage than the standard N.T.D. of a mixture of SA and GNC. Even when supplemented with SA, improvement in the cane tonnage of the mowhra cake treatment was not satisfactory.

Figures of number of millable canes at harvest and average weight of individual canes, the two factors which ultimately decide the cane tonnage, are available only for the last two years and are presented in Table II.

Table II

No. of canes and average weight of cane

Treatment	1953–54 No. of cane/acre	1953–54 Average wt/cane in lbs.	1954–55 No. of cane/acre	1954–55 Average wt/cane in lbs.
Mowhra Cake	24485	2·97	25671	2·61
Sulphate of Amm.+Mowhra cake	26719	4·00	28237	2·50
Sulphate of Amm.+G.N.C. ..	26736	4·35	30470*	3·56*
C.D. at 5%	6042	1·57	4140	0·46

The lower tonnage of cane on the mowhra cake N.T.D. in 1954-55 was due both to a lower number and a smaller size of the average cane compared to those harvested from the standard N.T.D. In 1953-54 though these differences are not statistically significant, the size of the average cane from the standard N.T.D. was decidedly better.

Growth Records

Periodical growth records of the crop maintained during the latter part of the field life, are presented in Table III. As already stated these figures could not be statistically examined.

TABLE III

Periodical changes in total length and weight of canes per average stool

Months of growth	Mowhra Cake		Sulphate of ammonia + mowhra cake		Sulphate of ammonia + Groundnut cake	
	Length inches	Weight lbs.	Length inches	Weight lbs.	Length inches	Weight lbs.
7	132·9	5·25	240·1	6·44	272·8	8·75
8	188·9	6.53	202·2	6·75	243·9	9·19
10	302·2	8·63	273·9	7·00	252·5	9·19
11	275·8	7·91	245·1	8·41	305·5	11·38
12	301·2	8·68	283·6	9·06	320·3	11·00
13	293·6	8·50	283·6	10·16	244·6	13·44

Due to the small size of the samples, the figures show appreciable scatter, but the better growth with sulphate of ammonia + groundnut cake is distinctly visible. Retardation of growth with mowhra cake dressings is continuous from the earlier stages and may be due to restricted supply of nitrogen. The sudden flush in growth appearing with mowhra cake dressing between 8 to 10 months may not indicate a sudden release of nitrogen during this period as a similar flush is absent with sulphate of ammonia + mowhra cake dressing. The lower length and weight per stool thus indicate a slower rate of growth due to short supply of nitrogen, since in sugarcane, growth rate is usually found to be proportional to the nitrogen supply (Cornelison 1940). The shortage of nitrogen in these two treatments is further supported by the quantity of nitrogen found per average stool (Table IV).

TABLE IV

Periodical changes in Nitrogen and Phosphate (P_2O_5) *per average stool*

Months of growth	Mowhra cake		Sulphate of ammonia + Mowhra cake		Sulphate of ammonia + G.N.C.	
	Nitrogen	Phosphate	Nitrogen	Phosphate	Nitrogen	Phosphate
7	3·06	2·58	4·12	2·70	5·61	2·41
8	5·13	4·00	5·07	[illegible]	7·40	3·90
10	4·91	3·68	2·99	2·53	7·51	3·33
11	3·37	3·75	3·64	3·33	7·20	3·54
12	3·56	5·60	3·69	3·66	5·54	4·55
13	3·48	5·15	3·23	4·75	5·38	5·36

At every stage of growth, nitrogen content of an average stool from the sulphate of ammonia + groundnut cake treatment is nearly twice that of the nitrogen content of the stools from the other two treatments. This had no effect on the phosphate content of the stools.

Nitrogen deficiency with mowhra cake dressing is further indicated by the nitrogen and moisture indices of the crop recorded during the growth period (Table V). They were determined as per method recommended by Clements (1942). Clements *et al.* have found them to show a correlation with the availability of nitrogen from the soil. The lower value of nitrogen index at different stages of the crop growth from the mowhra cake treatments may, therefore, be taken to indicate a restricted supply of the nutrient to the plants. This is again corroborated by the Moisture index of these two treatments which is consistently lower than on the standard N.T.D., a characteristic of nitrogen shortage observed by Clements (1943) and Dillewijn (1953). Phosphorus index of the crop from the three treatments is above the sufficiency level at all the stages of growth.

TABLE V

Nutrient indices of the crop

Month of growth	Moisture index			Nitrogen index			Phosphorous index		
	Mowhra cake	S/A+ M.C.	S/A + G.N.C.	Mowhra cake	S/A + M.C.	S/A + G.N.C.	Mowhra Cake	S/A + M.C.	S/A + G.N.C.
7	79·3	82·1	81·6	0·97	1·03	1·35	0·14	0·12	0·12
8	78·0	81·5	82·3	1·25	1·33	1·40	0·10	0·12	0·21
10	72·4	70·1	78·8	1·20	0·95	1·28	0·09	0·07	0·09
11	71·0	73·0	79·6	1·03	0·87	1·12	0·09	0·10	0·12
12	70·8	69·0	72·2	0·69	0·89	1·02	0·11	0·08	0·11
13	80·2	77·2	82·4	0·39	0·41	0·61	0·07	0·06	0·10

The low yield of cane repeatedly recorded from the mowhra cake dressings (Table I) may, therefore, be attributed to insufficient supply of nitrogen during the period of crop growth. As the same quantity of nitrogen was supplied in the form of the three top dressings, less supply of nitrogen from mowhra cake indicates that the cake nitrogen was not mineralised in the soil, sufficiently fast to meet the plant needs. The effect of a partial replacement of the cake with sulphate of ammonia was limited roughly to the extent of replacement. Mowhra cake thus appears to be very resistant to decomposition in soil over a long period and is not suitable as a fertilizer even to long term crops like sugarcane.

SUMMARY

1. Suitability of mowhra cake as nitrogenous fertilizer to sugarcane was studied.
2. A top-dressing of mowhra cake alone or partially supplemented with sulphate of ammonia consistently gave lower cane tonnage.
3. Growth rate on mowhra cake dressing was slow compared to that on the usual N.T.D.
4. Slow rate of growth was traced to the restricted supply of nitrogen from the fertilizer. Nitrogen content of an average stool as well as nitrogen index of the crop, treated with the cake were low throughout the growth period.

ACKNOWLEDGMENTS

The authors are thankful to the Sugarcane Specialist and the Agronomist, Sugarcane Research Station, Padegaon, for permission to take observation on the crop from the experiments in progress on the Agricultural Research Station, Padegaon.

REFERENCES

Clements, H. F. and Meriguchi, S. (1940). *Hawaii Plant Rec.*, 1942, 46: 163
———— (1944). *Rept. Univ. Haw. Agri. Expt. Stan.*, 1944: 34.
Clements, H. F. and Kubota, T. (1943). *Hawaiian Plant Rec.*, 1943, **44**: 273.
Cornelison, A. H. (1940). *Ibid.*, 1940, **44**: 273.
Dillewijn, C. Van (1952). Botany of Sugarcane. Publisher: The Chronica Botanica Co., 1952: 205, 209.
———— (1952). *Ibid.*, 1952: 209.
Hutcheson, (1921). *Agri. Res. Inst. Pusa, Sci. Reports*, 1920-21: 28.
Panse, V. G. (1945). Report of the I.C.C. Committee on manuring of cotton, 1945, Sept, 12.
Plymen, F. J. and Bal, D. V. (1922). *Agri. Jour. of India*, 1922, **17**: 551-59.
Rege, R. D. (1925). *Jour. Ind. Inst. Sci.*, 1925, **8A**: 245.
Annual Report, S.R.S., Padegaon, 1952-53: 119.
Ibid., 1952-53: 93.
Ibid., 1953-54: 86.

EFFECT OF SOIL APPLICATION OF INSECTICIDES ON THE PREMONSOON INCIDENCE OF BORERS AND GERMINATION OF SUGARCANE IN EASTERN UTTAR PRADESH

By

R. MUTHUSWAMY*

(Messrs. Begg, Sutherland & Co., Private Ltd., Marhowrah)

INTRODUCTION

SUCCESSFUL chemical control of borers in sugarcane crop is still a major problem to be solved by the research worker in India although much headway has been made in recent years in the control of *Pyrilla* and *Termites* with B.H.C. Endrin and Aldrin. The control of borers is not easy and often presents difficulties. One of the reasons for the failure of control of borers in the grower's fields with insecticides, reported to have given good results at the Research Stations in India, is the difficulty of applying the chemical during the oviposition period. The grower realises the borer attack only after the occurrence of dead-hearts.

Trials carried out by Messrs. Begg, Sutherland & Co., Private Ltd. (1954-58) in their estates by spraying Endrin (0·01 to 0·025 per cent), Folidol (0·044 per cent), Gamma B.H.C. (0·025 per cent) and D.D.T. + Lindane mixture (0·25 per cent) on the cane crop infested by the borers in the pre and post-monsoon periods have only shown partial reduction of borer attack.

Harbans Singh *et al* (1956) at Jullundur reported that only one spraying of Endrin at 0·1 per cent against third brood of the Top borer in July costing Rs. 32·5 per acre, was beneficial in not only controlling it but also in increasing the yield. The growers would certainly welcome any method of application of insecticides (provided it is within their reach) which would give them protection against borer attack during initial establishment of the crop. In this direction Gupta (1954) carried out a series of experiments and reported reduction in the incidence of shoot borer (*chilotraea infuscatellus*) in the hot weather period by the soil application of B.H.C. 5 lbs. actual per acre, over the setts at the time of planting. Similar observations have been made by Siddique (1957) who used high dose of Gammexane E.C. (B.H.C. Gamma Isomer) at the time of planting for the control of termites.

In view of the encouraging results recorded by the above workers, a field scale trial was laid out at Jugalganj Farm, Gauri Bazar (Eastern U.P.) to study the effect of soil application of a high dose of some of the modern insecticides at the time of planting. The results of these trials as regards germination of cane setts and incidence of borers in the premonsoon period are presented in this paper.

MATERIAL AND METHODS

The experiment was conducted in 5×6 randomised block in Bhangar soil devoid of termites. The plot in this experiment was 11 yds.÷11 yds. (1/40th acre) and there were 11 rows, 3 feet apart in each sub-plot. A buffer of 3 ft. width was left in between the sub-plots. Cos. 416, a variety with good tillering and susceptible to shoot borer *chilotraea infuscatellus* was planted in the experimental plots. Solutions of desired strengths of different insecticides were prepared by dissolving them in ordinary water and the setts were dipped before being planted. After the sett treatment the insecticidal solutions were diluted to 200 gallons per acre and sprinkled in the furrows over the setts by means of a kerosene tin perforated in one corner.

The following are the treatments tried.

T1. B.H.C. E.C. 5 lbs. (1 lb. actual Gamma Isomer per acre).

T2. Aldrin E.C. 2 lbs. actual per acre.

T3. Endrin E.C. 1 lb. actual per acre.

T4. Dieldrin E.C. 1 lb. actual per acre.

T5. Folidol E 605 (46·6 per cent), 1 lb. per acre.

T6. Control.

* Joined M/s. Parry & Co. Ltd., Madras.

For sett treatment 0·2 lb. actual insecticide was taken and dissolved in 10 gallons of water.

Thirty-three setts (100 buds) were planted in each row of the sub-plot. The crop was grown under irrigated conditions.

Observations

(1) Periodical counts on the total number of shoots germinated were taken at regular intervals till the germination was complete starting from 2nd week onwards and thereafter fortnightly counts on the number of tillers were recorded.

(2) During these observations, the total number of shoots affected by shoot, root and top borers were counted in each sub plot and the top leaves of affected shoots were clipped off after each observation, in order to distinguish the freshly attacked shoots in the subsequent observations.

The effect of soil application of the insecticides on the borer population was determined on the basis of number of dead-hearts noticed in the various treatments during the premonsoon period, at regular intervals. The species of borer available in the experimental plot were (1) Shoot borer (*chilotraea infuscatellus* snell), (2) Root borer (*Emmalocera depressella* swinh) and (3) Top borer (*Scirpophaga nivella* Fab.)

TABLE I

Shoot population per acre at different periods

Date of planting—1-3-58 Variety—Cos. 416.

Treatments	Germination count on				Number of tillers on		
	16-3-58	22-3-58	8-4-58	25-4-58	9-5-58	31-5-58	11-6-58
T1 Gamma BHC	968	12,304	16,904	19,512	41,656	64,544	71,968
T2 Aldrin	776	8,792	13,608	17,816	32,496	53,744	59,048
T3 Endrin	1048	13,176	17,840	21,160	47,464	76,848	77,584
T4 Dieldrin	1192	13,680	17,952	21,096	49,440	75,360	75,600
T5 Folidol	840	14,736	19,048	20,184	47,144	68,792	72,064
T6 Control	1088	13,864	17,992	20,496	41,736	63,144	66,456
S.E.	N. S.	527·20	514·40	N.S.	2294·80	2760·80	2390·00
C.D. at 5%	..	1555·20	1517·20	..	6769·60	8144·40	7050·40

Results and Discussion

Effect of Insecticides on Germination and Tillering:

A perusal of the data presented in Table I shows that the germination was considerably depressed by the application of 2 lbs. actual Aldrin (T2) while Dieldrin and Endrin seem to have produced some favourable effect after 7 weeks in the plots treated with these insecticides than in the control plot. The differences were, however, not statistically significant. Application of Gamma BHC. (T1) at 1 lb. actual per acre seems to have delayed the germination in the beginning.

The statistical analyses of the data confirmed these findings. The depressing effect of Aldrin and beneficial effect of Dieldrin on germination have already been reported by Harbans Singh (1954) and by the author (1957). It may be mentioned here that field trials carried out in "Begg, Sutherland's Group" factory areas (1956-57) revealed differential response of varieties to the treatment of pesticides, the deleterious effect of Aldrin being more pronounced in Cos. 416 variety (data unpublished). The harmful effect of Aldrin on germination was, however, completely masked when it was used with organo-mercurial fungicides (Aretan or Agallol) and the growth, stand and ultimate yield was greatly influenced by Aldrin (1958).

As regards the number of tillers, Endrin, Dieldrin and Folidol showed greater number of tillers than other insecticides tested in the order mentioned, while Aldrin continued to be inferior to all other treatments.

It is interesting to note that the number of tillers in plots treated with Endrin (T2) and Dieldrin (T4) was significantly greater than control (T6) and Aldrin (T2) while Gamma BHC and Folidol are on par with control. It may be noted that the number of tillers in the plots treated with 2 lbs. actual Aldrin (T2) was significantly less than control in all the observations indicating that the retarded germination due to heavy dose of this chemical applied over the setts in emulsion form had direct bearing on the total number of tillers produced. Similar observation on the deleterious effect of high dose of Aldrin was made by the author (1958) in the trial carried out at Marhowrah to find out the best formulation and concentration of Aldrin to be used for seed treatment of cane with and without organo-mercurial fungicides for protection against termites and hastening germination.

TABLE II

Incidence of the different species of borers (seizures per acre) at various intervals during premonsoon period

Treatment	Upto 7 weeks			7 to 9 weeks			9–5–58 to 31–5–58			31–5–58 to 11–6–58			Upto 11–6–58 (Total)		
	Root and shoot borer	Top borer	Total	Root and shoot borer	Top borer	Total	Root and shoot borer	Top borer	Total	Root and shoot borer	Top borer	Total	Root and shoot borer	Top borer	Total
T1 Gamma BHC	48	..	48	192	72	264	392	88	480	632	32	664	1,264	192	1,456
T2 Aldrin	248	..	248	272	280	552	608	248	856	672	48	720	1,800	576	2,376
T3 Endrin	72	..	72	184	176	360	160	64	224	200	48	248	632	288	920
T4 Dieldrin	272	..	272	648	592	1,240	856	432	1,288	672	72	744	2,448	1,096	3,544
T5 Folidol	616	..	616	1,120	608	1,728	2,000	680	2,680	1,344	144	1,488	5,080	1,432	6,512
T6 Control	680	..	680	952	544	1,496	1,072	504	1,576	1,024	168	1,192	36,48	1,216	4,864
S.E., ±	..	..	..	123·36	..	207·36	212·40	..	258·96	145·04	..	148·64	314·60	190·5	384·0
C.D. at 5%	..	..	..	364·00	..	611·60	626·40	..	764·00	426·00	..	438·40	928·80	562·0	1,132·8

Effect of insecticides on the incidence of Shoot, Root and Top borers:

A perusal of the results presented in Table II, shows that the variations in the infestation of different species of borers were well marked although the borer activity in general was comparatively less this year in the experimental plots. The incidence of shoot and root borers was highest in plots treated with Folidol closely followed by control and lowest in Gamma BHC followed by Endrin treatments. The population of these borers was medium in Aldrin and Dieldrin treatments and considerably less than control.

More or less the same trend was noticed at each observation till the break of monsoon rains except that Endrin showed superiority over Gamma BHC and other treatments in the last two observations. It is not understood how the top borer incidence was reduced by the soil application of insecticides as evidenced by the figures, especially when the borer starts its activity by tunnelling the midrib. Probably the repelling effect of chemicals might have had some effect on the top borer moth from laying eggs in the treated plots.

Efficacy of Insecticides in Reducing the Incidence of the Borers:

The overall incidence of borers in the various treatments in June was not more than 9 per cent, however, a statistical analysis of the data presented in Table III showed that the differences were highly significant and the percentage of decrease against control in the treatments except Folidol depicted quite a large variation ranging between 27·14 to 81·09 per cent. In the early stages Gamma BHC recorded the lowest number of dead-hearts closely followed by Endrin, but in the later stages the latter superceded the former.

In the 2nd week of May, the number of dead-hearts was 920 under Endrin, 1456 under Gamma BHC as against 4864 per acre in the control plot, the percentage of decrease against control being 91·09 per cent and 70·07 per cent under Endrin and Gamma BHC respectively. The infestation of borers in the plots treated with Aldrin and Dieldrin was 51·15 per cent and 27·14 per cent less than control respectively and

TABLE III

Overall incidence of borers in one acre

Treatments	Upto 7 weeks (24–5–58) Shoots		Upto 9 weeks (9–5–58) Shoots		Upto 12 weeks (31–5–58) Shoots		Upto (11-6-58) Shoots		Percentage of decrease or increase in the deadhearts over control
	affected	percentage	affected	percentage	affected	percentage	affected	percentage	
T1 Gamma BHC ..	48	0·246	312	0·743	792	1·242	1,456	2·017	–70·07
T2 Aldrin ..	248	1·392	800	2·449	1,656	3·077	1,656	4·087	–51·16
T3 Endrin ..	88	0·416	448	0·907	672	0·855	920	1·191	–81·09
T4 Dieldrin ..	272	1·289	1,512	3·120	2,800	3·682	3,544	4·642	27·14
T5 Folidol ..	616	3·052	2,344	4·960	5,024	7·284	6,512	9·029	–33·88
T6 Control ..	600	2·927	2,096	5·054	3,672	5·784	4,864	7·316	..
S.E. ± ..	..	..	204·8	0·458	330·80	0·449	384·0	0·529	..
C.D. at 5% ..	..	..	604·0	1·351	975·60	1·325	1132·8	1·561	..

the difference was statistically significant although the difference in between the two treatments was not significant. It may be noted that these two insecticides are significantly inferior to Endrin and Gamma BHC in giving protection to crop against borers as evidenced by significant increase in the overall percentage of borer incidence in June in the plots treated with Aldrin and Dieldrin over Endrin and Gamma BHC. The number of dead-hearts and percentage of borer attack were highest in the plots treated with Folidol throughout and in June the incidence was significantly higher than control and other treatments. It appears that this insecticide loses its insecticidal properties immediately after it is applied to the soil and has no effect on the incidence of borers.

Effect of Insecticides on Growth:

A critical examination of the crop in the various treatments of the experimental plots showed superiority of Endrin, Dieldrin, Folidol and Gamma BHC over Aldrin and control in growth in the order mentioned. It is proposed to undertake detailed study on growth of cane under different treatments at the time of harvest by measuring the length and number of internodes of individual stalks.

Comparative Cost of Insecticides:

As regards cost involved, the approximate cost per acre of the insecticides at the doses tried in the experiment are Rs. 65/- for Gamma BHC Rs. 35/- for Endrin, Rs. 21/- for Aldrin, Rs. 27/- for Dieldrin, and Rs. 30/- for Folidol. Thus out of all these, Endrin would appear to be the best as regards germination, tillering, protection afforded to the crop against various borers as well as from economic considerations.

SUMMARY AND CONCLUSIONS

The results of an experiment to study the effect of soil application of high doses of insecticides over the setts at the time of planting on the incidence of borers in sugarcane in the premonsoon period, conducted at Gauribazar (Eastern U.P.) have been reported in this paper.

Gamma BHC (1 lb. actual), Endrin (1 lb. actual), Aldrin (2 lb. actual), Dieldrin (1 lb. actual) and Folidol E 605, 46·6 per cent (1 lb.) were applied in the furrows in emulsion form and compared against 'control'. Assessments have been based on germination counts, tillering and the incidence of borers.

From the data collected, it is evident that (1) good control of borers in the premonsoon period can be obtained by the soil application of 1 lb. actual Endrin or Gamma BHC. (2) Folidol has no effect on the incidence of borers when applied to the soil. (3) Borer incidence is considerably reduced by the

application of 2 lbs. actual Aldrin or 1 lb. actual Dieldrin . (4) Germination is depressed significantly by the application of 2 lbs. actual Aldrin per acre and to some extent by Gamma BHC as well; while it is influenced slightly by Folidol.

It remains to be seen whether the cost of insecticides at the doses tried would prove economical especially for cane crop grown under rainfed conditions in North Bihar and Eastern U.P. Further studies have to be taken up to arrive at the optimum dose of Endrin and Gamma BHC to be applied, their effects under condition of serious borer and termites infestation, post-monsoon attack of borers, growth and roots of cane, different varieties under different soil conditions before any recommendation could be made. It is also proposed to carry out trials with the above insecticides in combination with organo mercurial fungicides (*Aretan* and *Agallol*) to offset the depressing effect of high dose of insecticides on germination.

ACKNOWLEDGMENTS

Grateful thanks are due to Mr. D. Ramanujam, Agricultural Advisor, M/s. Begg, Sutherland & Co., Private Ltd., Marhowrah for suggesting the work and providing facilities for carrying out the trial. Thanks are also due to Shri A.S. Greval and Shri I. B. Sen Gupta of Cawnpore Sugar Works, Gauribazar for their assistance in recording observations.

REFERENCES

Anonymous (1955-56, 1956—57). Investigational Reports of M/s. Begg, Sutherland & Co.(P), Ltd., Marhowrah.
Gupta, B. D. (1954). *Proc. 2nd. Bien. Conf. Sug. Res. & Dev. Workers, India*: 204-206.
Harbans Singh, Kalra, A. N. and Sidhu Ajit Singh (1956). *Ind. Jour. Sug.cane Res. & Dev.*, Vol. **I:** Part I.
Muthuswamy, R. (1957). *Proceedings of 3rd. Bien. Conf. Sug. Res. & Dev. Workers*, India.
Muthuswamy, R. (1957). Proceedings of Indian Standards Convention T.5 Section Doc. A.M 14.
Muthuswamy, R. and Aravamudhan, P. (1958). *Ind. Jour. Sug.cane Res. & Dev.*, Vol. **II**, Part 2, 1958: 61-70.
Muthuswamy, R. (1958). Studies on different formulations and doses of Aldrin used for seed treatment of cane with and without Aretan (Unpublished data).

SOILS OF THE SUGAR FACTORY ZONE, HAMIRA (PUNJAB)

By

J. M. Sharma, S. S. Saini and D. R. Dhingra

(Sugarcane Research Station, Jullundur Cantt., Punjab)

Introduction

The preliminary studies on the soils of the Hamira Factory Zone in the Punjab have been completed on the lines already reported by Dass and others (1954) and Sharma *et al.* (1958). These studies were initiated to gather some systematic knowledge of the soil types in various sugar factory zones to be utilized for proper development of cane cultivation on scientific lines as emphasized by Mukerji (1951). This information regarding general characteristics of the soils will go a long way in solving various soil problems in relation to general agriculture and is an essential prerequisite for working out manurial, irrigational and cultural schedules for different crops cultivated on various soil types.

Geographical and Climatic

Hamira Factory Zone consists of 305 villages comprising the cultivated area of about 1,50,407 acres (235·0 sq. miles). The area is situated about 9 miles East of river Beas comprising some areas of Jullundur and Hoshiarpur Districts of the Punjab. Kapurthala Bain (small stream) flows on the Western side of the zone in the North South direction at a distance of about two miles. On the North of the factory zone several seasonal streams (locally known as chos) flow in the East West direction and finally feed Bain Nalla. It lies between latitudes 31°·0′ and 31°·5′ N. The general topography of the area is flat except some low lying areas in the North and North-East where water logged soils occur as reported by Sharma and Singh (1958).

The climate of the area in general may be described as semi-arid. The weather is clear and the sunlight intense for the greater part of the year. The meteorological data in respect of maximum temperature, minimum temperature, average precipitations and relative humidity as recorded at Jullundur is given in Table I

TABLE I

Meteorological data—Average of five years 1953-57

Month	Mean Maximum temperature F°	Mean Minimum temperature F°	Rainfall in inches	Mean relative humidity %
January	64·9	41·2	2·07	93
February	72·5	45·5	1·27	90
March	82·9	54·8	1·87	83
April	93·5	61·4	0·34	62
May	102·4	72·2	0·23	49
June	104·1	79·4	1·21	54
July	95·0	78·9	10·26	81
August	92·7	77·7	5·94	85
September	92·9	73·9	4·95	83
October	87·4	60·7	8·03	84
November	81·0	46·4	0·17	87
December	70·5	42·5	0·67	90

The highest maximum temperature recorded at Sugarcane Research Station, Jullundur was 114·5° F and lowest minimum temperature 28·4° F. The maximum annual precipitation recorded was 53·93″ and minimum 18·14″. The average annual rainfall of this area is 29·9″.

Soils

The alluvial soils of the Hamira factory zone show different profile maturity due to variable topographical conditions and other associated features. The river, nallas and seasonal streams have played an important role in the development of soils in the sugar factory area. On the basis of the study of 76, six feet deep or upto sub soil water level, soil profiles in situ and results of the physicochemical characteristics, these soils have been classified into four soil types. The various soil types have been discussed as under:—

1. *Type II soils*—The soils are moderately matured and generally impregnated with calcium carbonate concretions in the sub-soil horizons within six feet deep solum. These soils occur in the form of a strip on the Eastern side of the zone comprising an area of about 30081 acres or about 20·0 per cent of the total area of the Hamira factory zone. These soils in general are fairly well drained with the exception of certain localised areas where soils have developed under impeded drainage due to the formation of kankar pan in the sub-soil. The range of the surface texture varies from sandy to clay loam. These soils are of low to medium fertility and all sorts of crops are cultivated on these soils.

The morphological characteristics and physicochemical analysis of type II soil profile are given in Table II and III.

TABLE II

Morphological characteristics of type II clay loam profile

Depth	Morphological description
0″– 8″	Light grey, more grey when wet; clay loam; crumb structure; roots and insect holes present; slightly moist; slight effervescence with Hcl.
8″–39″	Dull grey, dark grey when wet; clay loam; hard and compact; tertiary roots in scanty; holes of termites present; slightly moist; slight effervescence with Hcl.
39″–56″	Whitish grey, grey when wet; clay loam; less compact than above horizon; greyish white streaks of calcium carbonate present; slightly moist; effervescence with Hcl.
56″–72″	Light greyish yellow, yellowish grey when wet; clay loam; hard and compact; cloddy structure; carbonate concentrations and small sized ferrogenous nodules present; moist; profuse effervescence with Hcl.

TABLE III

Depth of the horizon	0″–8″	8″–39″	39″–56″	56″–72″
Clay %	20·15	22·00	24·85	23·70
Silt %	23·20	24·00	22·45	24·05
Sand %	54·56	53·96	51·99	50·45
Calcium Carbonate %	0·85	0·82	0·50	1·15
Organic carbon % (Walkley and Black value) ..	0·576	0·103	0·096	0·069
Water holding capacity %	25·00	40·20	40·60	40·10
Sticky point moisture %	22·0	23·20	24·20	24·60
Ionizable salts %	0·201	0·180	0·273	0·184
pH value	7·5	7·5	7·8	7·75
Total nitrogen %	0·1008	0·0392	0·0322	0·0280
Total Cao %	0·763	0·924	0·938	0·994
Total P_2O_5 %	0·39	0·122	0·121	0·105
Total K_2O %	1·30	0·80	1·30	1·00

The soil is light greyish in colour and moderately matured with the development of distinct horizons. It is fairly leached soil with illuviated horizon of $CaCo_3$ concentrations. The greater clay content in the lower layers indicates mechanical eluviation but there was no major textural variation since the texture of all the horizons fall under the group of clay loam. The mobilization of clacium carbonate and sesquioxide is evident due to their deposition in the sub soil horizons in the form of kankar and ferrugenous nodules. pH value show an increase with the depth of the solum. Total organic carbon, nitrogen and C/N also show a regular decrease with the depth.

2. *Type III soils* —These soils are characterized due to the presence of illuviated horizons of ferrugenous nodules within six feet profile depth. The soils are fairly matured and generally well drained. The soils are light in texture and generally fall under the group sandy loam except some areas of heavy texture on the North of the factory zone. The range of surface texture varies from sandy to clay loam. These soils occur in the central areas of the factory zone comprising an area of about 99,000 acres constituting about 56 per cent of the total area. The morphological characteristics and physico-chemical analysis of type III soil profile are given in Tables IV and V.

TABLE IV

Depth	Morphological description
0″–20″	Yellowish grey, dull yellowish grey when wet; sandy loam; single grain structure; roots and insect holes present; dry; slight effervescence with Hcl.
20″–48″	Yellowish brown, light greyish brown when wet; crumb structure; roots scanty; slightly moist; slight effervescence with Hcl.
48″–69″	Light brownish, greyish brown when wet; sandy clay loam; cloddy structure; ferrogenous nodules present; slightly moist; no action with Hcl.
69″–72″	Yellowish brown, greyish brown when wet; sandy loam; crumb structure; moist; no action with Hcl.

TABLE V

Depth of horizons	0″–20″	20″–48″	48″–67″	67″–72″
Clay % ..	14·47	26·00	27·25	13·30
Silt % ..	8·47	17·10	17·25	10·55
Sand % ..	75·99	56·58	54·57	76·01
CaCo 3 % ..	0·56	0·00	0·00	0·00
Organic Carbon % (Walkley and Black value) ..	0·237	0·147	0·107	0·066
Water holding capacity % ..	31·4	37·2	37·4	25·0
Sticky point moisture % ..	23·1	23·3	24·5	20·50
Ionizable salts % ..	0·175	0.232	0·232	..
pH value.. ..	7·31	7·00	6·95	6·90
Total nitrogen % ..	0·05	0·055	0·034	0·031
Cao. % ..	0·539	0·490	0·590	0·049
P_2O_5 % ..	0·137	0·114	0·135	0·124
K_2O % ..	1·037	1·338	1·220	0·981

The soil is yellowish grey in colour well drained, matured showing development of distinct profile horizons and occurrence of illuviated horizon of ferromanganeferous nodules. The greater concentration of clay in the second and third horizon indicates pronounced mechanical eluviation. The soil profile is devoid of free calcium carbonate except the presence of small quantities in the surface horizon which might

have been added through the application of farm yard manure or artificial fertilizers by the cultivators. There is a regular decrease in the pH and total ionizable salts with the depth of the solum. Like soil type II organic carbon and total nitrogen contents decrease with depth of the profile.

3. *Type IV Soils.*—These are heavily leached soils due to the flood action of seasonal streams. These soils occur on the North West and North East of the factory zone. The soils are well drained and are low to medium in potential fertility status. The soils are generally light in texture and surface texture varies from sandy to sandy loam. These soils comprise an area of about 12,784 acres, thus constituting about 18·5 per cent of the total area of the sugar factory zone. The morphological characteristics and physico-chemical analysis of type IV soil profile are given in Table VI and VII.

TABLE VI

Depth	Morphological Characteristics
0″–6″	Dull yellowish brown, greyish brown when wet; sandy; single grain structure; roots and insect holes present; no action with Hcl.
6″–34″	Bright brown; light greyish brown when wet; sandy loam; single grain structure; slightly more compact than upper horizon; roots scanty; no action with Hcl.
34″–44″	Greyish brown, brownish grey when wet; loamy sand; single grain structure; slightly moist; no action with Hcl.
44″–72″	Dull yellowish grey, grey when wet; sandy; loose and porous; moist; no action with Hcl.

TABLE VII

Depth	0″–6″	6″–34″	34″–44″	44″–72″
Clay %	8·10	16·00	12·00	7·95
Silt %	1·8	8·75	6·50	3·35
Sand %	90·03	75·05	81·41	88·65
$CaCo_3$ %	0·00	0·00	0·00	0·00
Organic Carbon % (Walkley and Black Value) ..	0·31	0·093	0·044	0·025
Water holding capacity %	24·6	28·3	29·0	24·10
Sticky point moisture %	20·0	16·3	17·20	18·20
pH Value	6·40	6.50	6·70	6·70
Total nitrogen %	0·02	0·032	0·029	0·018
Total Cao %	0·30	0·50	0·48	0·30
Total K_2O %	1·85	0·857	0·796	0·535

The surface soil is dull yellowish brown in colour and it darkens on wetting. The increase in the percentage of clay and silt fraction in the second horizon indicates the mobilisation of these fractions due to pronounced leaching. The profile is devoid of free calcium carbonate and the pH value progressively increases with the depth and it varies from 6·4 to 6·7. The organic carbon and total nitrogen contents decrease with the depth of the solum. The soils are poor in reserve of calcium.

4. *Type VI soils.*—These are water logged soils with impeded drainage due to high water table and are characterised by the concentration of soluble salts and calcium carbonate in the surface horizon. These soils occur in the North Western side of the factory zone comprising an area of 8,000 acres. The morphological characteristics and physico-chemical analysis of type VI clay loam profile are given in Table VIII and IX.

The soil is greyish brown in colour and heavy in texture. Sub soil water oozes out at a depths of 33″. High concentration of water soluble salts and calcium carbonate has been recorded in the surface layer. The accumulation of silt and clay in the surface layer is higher as compared to the sub soil horizons and the

soil texture becomes lighter with the depth of the solum. pH value also shows decrease with the depth and it varies from 7·9 to 6·10. The percentages of various soil minerals do not show any regular distribution in various horizons.

TABLE VIII

Depth	Morphological description
0″–15″	Light greyish brown, greyish brown when wet; clay loam; compact; rootsand insect holes presen slightly moist; profuse effervescence with Hcl.
15″–33″	Light brownish grey, dull brownish grey when wet; clay loam; compact; roots present; yellowish brown spots of iron; slight effervescence with Hcl.
33″–72″	Greyish yellow, dull yellowish grey when wet; clay loam; compact; roots scanty; short sized ferro-manganeferrous nodules; water oozes out; no action with Hcl.

TABLE IX

Depth of the horizon	0″–15″	15″–33″	33″–72″
Clay %	24·70	22·00	23·15
Silt %	26·60	28·25	26·60
Sand %	48·70	44·75	50·25
$CaCo_3$ %	3·35	0·67	0·00
Organic Carbon % (Walkley and Black value) ..	0·555	0·231	0·261
Water holding capacity %	49·70	58·60	61·80
Sticky point moisture %	29·50	36·60	43·40
Total Water soluble salts %	0·366	0·268	0·223
pH Value	7·90	7·30	6·10
Total nitrogen %	0·084	0·0378	0·056
Total Cao %	1·58	0·48	0·51
Total P_2O_5 %	0·308	0·297	0·419
Total K_2O %	1·31	1·30	1·26

DISCUSSION

The principal parent material from which the soils of the Hamira factory zone have developed is primarily water borne. Topography and physiographic position of the soils is important in determining the length of time the soil material have been subjected to the action of soil forming forces which are responsible for the development of the soils and their physico-chemical characteristics. In the soils from the more recent alluvial deposits, which are moderately matured the calcium carbonate is accumulated in a definite light grey layer which in places also forms a hard kankar pan. These soils have been designated as type II soils. The more matured soils are light brown or yellowish to greyish brown in colour. They contain little organic matter and their decomposing iron compounds are highly oxidized and relatively unhydrated. These soils are characterised by the mobilisation of finer soil fractions into the sub soil horizons and illuviated horizons of ferrugenous nodules that probably results from the hydrolytic decomposition of certain soil minerals. Such soils have been categorized as type III soils. The drastically leached soils developed under the flood action of the seasonal streams have been classified as type IV soils. These soils are neutral to faintly acidic in nature. Type VI soils have developed in low lying areas under the influence of impeded drainage. The sub soil water oozes out under hydrostatic pressure and the water table fluctuates periodically under variable weather conditions. The soils of semi-arid regions generally contain lower amounts of organic matter and total nitrogen and this tendency is amply reflected

in the soils of Hamira factory zone. All sorts of crops are cultivated on all the soil types in the Hamira factory zone under the suitable management practices depending upon the available irrigation facilities except on type VI soils where sugarcane and rice are the principal crops. The general potential fertility status of the soils as reported by Sharma and Singh *loc cit.* is in the order of type II $\gtrdot$ type III $\gtrdot$ type IV $\gtrdot$ type VI soils.

ACKNOWLEDGMENT

The authors are indebted to the Indian Central Sugarcane Committee which partly finances the scheme under which these investigations were carried out.

REFERENCES

Ann. Rep. Sug. cane Res. Scheme, Punjab (1954-55).
Das, B., Singh, H., De, R. and Saini, G. R. (1954). *Proc. 2nd. Bien. Conf. Sug.cane Res. & Dev. Workers,* India.
Sharma, J. M., De. R., Saini, S. S. and Singh, H. (1958). *Ind. Jour. Sug.cane Res. & Dev.,* Vol. **II**, Part 4.
Sharma, J. M. and Singh, H. (1958). *Ibid.,* Part 3.
Mukerji, B. K. (1951). *Proc. 1st Bien. Conf. Sug.cane Res. Workers,* India.

IMPROVED TECHNIQUE OF GUR MANUFACTURE AND THE ROLE OF VARIOUS CLARIFICANTS

By

*K. C. Joshi and S. N. Pandit

(Indian Institute of Sugarcane Research, Lucknow, Uttar Pradesh)

ALTHOUGH the Industry of manufacturing *Gur* (Jaggery) from sugarcane is known in India from time immemorial, the different aspects of the processes involved are neither fully understood nor even followed correctly. The technique as a whole also offers much scope of improvement.

The process of the manufacture of *Gur* consists of the following two main operations:—

(i) Crushing of Sugarcane for extracting maximum amount of juice therefrom, and (ii) clarifying and boiling the juice to a point that would make it solid or semi-solid (depending on local preference) mass when cooled.

Various types of crushers, either animal or power-driven are available now-a-days for crushing cane for the extraction of juice. The most primitive form of crusher had been a wooden implement resembling a huge pestle and mortar driven by animal power. This later gave place to wooden crushers of two rollers placed vertically close to each other. But now three-roller cast iron crushers of horizontal or vertical type are in use everywhere. Bullock-driven crushers are now commonly used by cane growers for the extraction of juice for *Gur*.

Clarification and Boiling

Clarification of cane juice and its final boiling to proper consistency is done in furnaces commonly called Bels. As the inversion of sucrose and the formation of non-sugars start in juice very soon after its extraction, the boiling of the juice must take place with as little time gap and as speedily as possible.

Numerous types of *Bels* are in use in different parts of India. In northern India the *Bels* most commonly found are the 'Rohilkhand Bels' of three or five pans and the 'Meerut Bel' of three pans while in the South the most common is the 'Poona Bel' of three pans. In Eastern India the 'McGlashan' furnace and 'Improved South Bihar' furnace are very much in vogue. Besides these furnaces, there are numerous others big and small, which gain preference in different localities. But most of these furnaces, excepting the 'Improved South Bihar' furnace are too big to be of any use to small *Gur* producers.

In order to meet the requirements of small *Gur* manufacturers, one small multiple pan *Gur* boiling furnace was designed at this Research Station. This furnace was tested against the 'Improved South Bihar' Furnace which is very popular in the Eastern region of the country. The data collected during the tests are given in Table I in a consolidated form.

It will be observed from Table I that 'Bilari *Bel* No. 1' has definitely a lower fuel consumption though its efficiency in terms of pol in *Gur* percent pol in juice is almost equal to that of 'Improved South Bihar' furnace. Juice boiling capacity of 'Bilari *Bel* No. 1' is more than double to that of 'Improved South Bihar' furnace. Thus for small scale producers of *Gur* it will prove to be an ideal furnace having all the advantages of a bigger unit.

Clarification

The first step in the actual manufacture of *Gur* is the process of clarification. An efficient handling of this process is primarily responsible for the quality of *Gur* produced.

The raw cane juice contains all the soluble matter in the cane, including sucrose and glucose. Also it contains in suspension colloids, wax, colouring matter, albumen, gums, fine particles of bagasse, mud etc. These suspended matters, if allowed to remain, would impart a disagreeable colour and taste to the resulting product. Clarification is, therefore, necessary to get rid of the suspended matter in juice as completely as possible.

The clarification for *Gur* making may be done in two ways viz: (a) by Vegetable clarificants alone or (b) by Vegetable clarificants along with chemicals.

*This paper was written up by the junior author after the death of Shri K. C. Joshi.

TABLE I

Sl. No.	Particulars	Improved South Bihar Furnace	Bilari Bel No. 1
1	Hours worked	30·017	26·45
2	Juice Boiled .. Mds. ..	52·14	93·20
3	Juice Boiled per hour	1·74	3·52
4	*Gur* produced	8·0	14·27
5	Bagasse burnt	21·83	32·13
6	Bagasse burnt % juice	41·87	34·47
7	Extra fuel required per 100 canes (with 6% moisture)	5·21	0·70
8	Analysis :—		
	juice: Brix	18·58	18·58
	Pol	14·60	14·60
	Purity	78·58	78·58
	Gur: Brix	96·90	97·12
	Pol	68·42	68·53
	Purity	70·61	70·56
9	Water evaporated	42·14	75·37
10	Water evaporated per hour	1·40	2·85
11	Heating surface sq. ft.	7·07	19·45
12	Efficiency :		
	Water evaporated per sq. ft. heating surface per hour	0·198	0·15
13	Maunds Pol in Juice	7·612	13·607
14	Maunds pol in *Gur*	5·474	9·779
15	Pol in *Gur* % Pol in Juice	71·91	71·87
16	Temperature at the 1st pan (grate) ..	810°C	850°C
17	Temperature of fuel at chimney	630°C	260°C
18	Difference in temperature (16–17)	180°C	590°C

VEGETABLE CLARIFICANTS

In the manufacture of *Gur* and *Rab* (massecuite) by open pan process, various vegetable clarificants are used to facilitate the removal of scum from raw juice. The vegetable clarificants commonly used are: Deola (*Hibiscus ficulneus*), Bhindi (*Hibiscus esculentus*), Sukhlai (*Kydia calisina*), Semal Bark (*Bombax malabaricum*), Falsa (*Grewa asiatica*), Groundnut (*Arachis hypogoea*), Castor Seed (*Ricinus communis*), etc.

Almost all the clarificants mentioned above have actually been repeatedly tested by the authors at the *Gur* and *Khandsari* Research Scheme in order to find out the comparative efficiencies of these. The data collected during the most recent trial conducted by the authors during the season 1952-53 are presented in Table II.

These trials were conducted in two replications of which the percentage of colour removed in the clarified juice as compared to the initial colour present in the raw juice, were as follows.

TABLE II

Sl. No.	Treatment for clarification	Percent colour removed		Mean
		Rep. 1	Rep. 2	
1	Deola	49·82	49·48	49·65
2	Groundnut	49·04	49·04	49·04
3	Sukhlai	48·87	48·70	48·79
4	Semal Bark	48·34	48·35	48·35
5	Castor Seeds	46·79	46·79	46·79

Bhindi and Falsa could not be tried this season as these could not be procured during the period of these trials though these two clarificants were tried by the senior author at the Sugar Research and Testing Station, Bilari during the season 1939-40.

On a statistical analysis the present data shows that at 5 per cent level Deola proves to be the best, while the clarifying efficiency of the clarificants are in the following descending order:—

1 Deola
2 Groundnut
3 Sukhlai
4 Semal Bark
5 Castor Seed

The difference between the efficiency of Groundnut and Sukhlai was not significant at 5 per cent level.

The standard error for the treatments is $\pm$ 0·0770 and critical difference is 0·3022 at 5 per cent level.

The mean of all the other data collected during the experiment have been shown under Appendix 'A'.

CHEMICALS ALONG WITH VEGETABLE CLARIFICANTS

The chemical clarificants are generally used as a supplement to the vegetable clarificants in order to give more lustre and brilliance to the product. The chemical clarificants generally used are (i) Lime Water, (ii) Sajji, (iii) Soda-Ash, (iv) Sodium-bi-sulphite, (vi) Sodium Carbonate, (vii) Sodium bi-carbonate, (viii) Superphosphate and (ix) Edicol Supra Tartrazine Ns. But most of these have been found to affect the taste and keeping quality of the *Gur* adversely and their clarifying effects are very temporary.

Out of the chemical clarificants mentioned above the use of Edicol Supra Tartrazine Ns and Sodium-bi-sulphite are comparatively of recent origin. These chemicals were, therefore, tried by the authors for finding out their suitability for improving the colour of *Gur* without in any way affecting its flavour.

(i) Edicol Supra Tartrazine Ns is the trade name of a colouring powder produced by the Imperial Chemical Industries for imparting a golden colour to *Gur*. During the trials conducted by the authors the chemical was added to *Gur* in the cooling pan at the rate of 1 gram per 1,600 lbs. of juice. The resulting product was compared with the *Gur* produced by ordinary 'Deola' clarification. Trials were conducted in five replications of which the data relating to the percentage of colour removed in *Gur* as compared to that initially present in the raw juice are given in Table III.

The value of 't' from the above observation is 3·0008; which is significant at 5 per cent level. Deola clarification alone is significantly superior to Deola along with a dose of Edicol Supra Tartrazine Ns added in the cooling pan, when the aim is to remove as much colour from the *Gur* as possible.

The determination of colours for the above experiment were done with a Lovibond Tintometer. Colour present in *Gur* was determined from a 13 per cent solution of the same. Appendix 'B' shows the mean of all the data collected. It will be evident from this appendix that the Edicol Supra Tartrazine Ns imparts some additional red and yellow colour to the *Gur*. As a result of this the colour of *Gur* becomes darker and hence is not liked by the consumers.

(ii) Sodium-bi-sulphite was tried by the authors in different doses for impoving the colour of *Gur*. The chemical was added twice during the course of juice boiling. Three different doses were tried @1·36

TABLE III

Sl. No.	Per cent colour removed in *Gur*	
	With Deola alone	With Deola and Edicol Supra Tartrazine Ns.
1	21·82	17·58
2	19·88	13·04
3	21·30	19·53
4	23·08	19·53
5	19·88	14·90
	Mean .. 21·19	16·92

lbs., 1·79 lbs. and 3·07 lbs. per 100 mds. of juice. The full dose was added once just after the juice has been clarified with 'Deola' and was repeated again after the clear juice has been concentrated to half its original volume. The removal of colour achieved by the different doses of chemical, was compared to that done by 'Deola' alone. The comparative figures for the percentage of colour removed as compared to the colour present initially in the raw juice, are shown in Table No. IV, compiled from two replications of the trial.

TABLE IV

Sl. No.	Treatment	Per cent colour removed		Mean
		Rep. 1	Rep. 2	
1	Deola alone	48·32	48·11	48·22
2	Deola plus Sodium-bi-sulphite@1·36 lbs. per 100 mds. of juice	49·38	49·20	49·29
3	Deola plus Sodium-bi-sulphite@1·79 lbs. per 100 mds. of juice	49·91	49·01	49·46
4	Deola plus Sodium-bi-sulphite@3·07 lbs. per 100 mds. of juice	50·18	49·82	50·00

On statistically analysing the data it has been found that at 5 per cent level the increasing doses of Sodium-bi-sulphite used are significantly superior to the usual clarification of juice with Deola alone, the standard error being $\pm$·1684 and critical difference at 5 per cent level $\pm$·7572.

It was also observed that the addition of this chemical up to the maximum dose did not affect the taste or flavour of the *Gur* in any way and the improvement in colour did not disappear even after a month's storage. But the manner in which the addition of this chemical will affect the keeping quality of *Gur* or whether the consumption of such *Gur* will affect the human system in any way, had not been investigated. The mean of all the data collected during the experiments have been given under appendix 'C'.

BOILING

After the clarification is complete, the juice has to be boiled to the proper consistency. This boiling has to be quick and vigorous in order to give the least possible opportunity to the micro-organisms and free acids to invert the sucrose and to produce non-sugars. The exact time at which the boiling mass has to be taken out from the furnace is judged by the workers by experience from an eye estimation only. If the boiling has proceeded too far there will be caramelisation and in case it is under-boiled, no solidification will take place. An emulsion of Castor seed in water is often sprinkled on the juice for controlling the frothing in boiling juice and thus having a proper judgement of the stage of boiling.

When the boiling has proceeded sufficiently, the heat in the furnace is slowed down by controlling its feeding with fuel, and the mass in the pan is constantly stirred by a wooden stirrer in order to prevent

caramelisation by local heating at any point. This is continued until the exact 'striking point' i.e. the time at which the mass has to be taken out of the furnace is reached.

The striking point as found by the authors corresponds to temperatures ranging from 116 C to 120 C depending on the nature of *Gur* required. This is invariably judged by the eye estimation and never by a thermometer. There are various methods to judge the striking point of *Gur* some of which are described below.

1. When the boiling is found to have sufficiently advanced as to have reached the striking point a small quantity of the boiling mass is thrown in cold water. If the mass can be formed into a small solid ball which produces a metallic sound when thrown against the metallic pan, the boiling is regarded as complete.

2. On reaching the striking point the mass when stirred with the wooden stirrer (as already told) would leave the bottom of the pan clear.

3. In practice the striking temperature is generally about 118 C for *Gur*. Now if the stirrer is held out in the air over the pan before the striking point is reached the sticking mass falls down in thick threads, but at the striking point these would form long, thin dry threads flying in the air.

Cooling of Gur

When the striking point of *Gur* is reached, the mass is taken out from the furnace and is transferred to a shallow iron or earthen pan for cooling. This special cooling pan is commonly known as 'chak'. Here the mass is left for some time to cool upto a point when its upper layer has solidified but the inner mass is still hot and semi-solid.

The mass is then stirred vigorously with an iron or wooden implement called 'Khurpi'. This stirring completes the process of *Gur* making. It may now be left for some time more on the 'Chak' (cooling pan) to be scraped out later in small 'laddus' or 'Ginauras' or it may be at once transferred to some suitable mould according to the shape in which the *Gur* is desired to be had.

Conclusion

The use of chemicals for the manufacture of *Gur* at any stage is not advisable. *Gur* manufacturers are often tempted to use some kind of chemical either in clarification or in the cooling pan before stirring in order to have an unnatural brilliance in the colour of their product. But it is often forgotten that in most cases this adversely affects the taste. The peculiar *Gur* flavour for which the material is prized in our country is lost to a very great extent even when only moderate quantities of a chemical have been used. In the case of certain chemicals like Sodium-hydro-sulphite, the disagreeable flavour is so pronounced that it can be felt even by smell. Further the use of chemicals introduce inorganic salts in *Gur* thus adversely affecting its keeping quality. It may, however, be advisable to use chemicals like Lime water or Soda under special circumstances when the juice is of a very inferior quality, the *Gur* from which would otherwise create difficulty in setting.

The main improvements that can be effected in the economical production of *Gur* are to maximise extraction by the use of a good crusher and to make the clarification and boiling more efficient by using a a good clarificant and a good furnace. Particular attention need be given in the selection of these things.

The "Kolhu" should be strong and rigid in construction, light in running and should give maximum extraction of juice. As no trained mechanic or any workshop facility is available in the villages where crushers are generally worked the breakages should be least.

The juice boiling furnace also has to be the most efficient possible in order to be economic. It should boil the juice quickly and efficiently. The fuel used should be able to produce the maximum amount of heat and the furnace should be able to utilize the heat to the fullest extent for juice boiling. As a result of researches at the *Gur* and *Khandsari* Research Scheme of the Indian Institute of Sugarcane Research, Lucknow, quite a number of bels, big and small, have been designed with the above points in view. Those bells consume the least quantity of fuel and give the maximum efficiency and juice boiling capacities for their respective sizes.

However, from the observations made by the authors as given in the Tables, it has been found that *Gur* making on a small scale can most economically and efficiently be done if the time old furnaces are replaced by more efficient furnaces like 'Bilari Bel' and simple 'Deola' is used as a clarificant instead of other chemicals, etc.

Appendix 'A'

Comparative efficiencies of Castor Seed and other vegetable Clarificants of cane juice

Sl. No.	Particulars	Clarificants				
		Deola	Groundnut	Sukhlai	Semel bark	Castor Seed
1	Weight of Juice .. .. Mds.	59·03	46·06	36·28	34·68	28·22
2	Weight of Clarificant .. .. Lbs.	2·22	3·09	1·47	1·73	1·81
3	Weight of Clarificant on 100 maunds juice Lbs. ..	3·76	6·71	4·05	4·99	6·41
4	Raw Juice:—					
	(a) Brix	20·12	19·94	19·99	20·10	19·87
	(b) Pol	16·58	16·53	16·58	16·58	16·48
	(c) Purity	82·36	82·90	82·94	82·49	82·94
	(d) PH	5·5	5·5	5·5	5·5	5·5
	*(e) Colour:—					
	(i) Yellow	31·0	31·5	31.9	31·4	30·5
	(ii) Red	19·5	19·3	19·3	19·6	19·3
	(iii) Blue	6·3	6·3	6·4	6·3	6·2
5	Clarified Juice:—					
	(a) Brix	20·98	21·16	20·82	20·76	21·17
	(b) Pol	17·21	17·44	17·13	16·98	17·50
	(c) Purity	82·03	82·42	82·28	81·79	82·67
	(d) PH	5·4	5·4	5·4	5·4	5·4
	*(e) Colour:—					
	(i) Yellow	20.1	21·0	20·8	20·6	21·7
	(ii) Red	6·1	5·8	5·8	6·4	5·5
	(iii) Blue	2·4	2·3	2·9	2·6	2·6
	(f) Colour % removed	49·65	49·04	48·79	48·35	46·79
6	*Gur*:—					
	(a) Brix	96·59	96·72	96·88	96·65	96·83
	(b) Pol	72·61	73·37	73·21	72·27	73·55
	(c) Purity	75·17	75·86	75·57	74·78	75·96
	*(d) Colour:— (13% solution)					
	(i) Yellow	17·5	17·8	17·8	17·5	18·2
	(ii) Red	5·6	5·6	5·6	6·0	5·4
	(iii) Blue	2·1	2·1	2·3	2·4	2·6

*By Lovibond Tintometer

Appendix 'B'

Comparative Efficiency of Deola as compared to Deola supplemented by Edicol Supra Tartrizine Ns. in Cooling Pan.

Particulars	Deola alone	Deola clarification and Edicol Supra Tartrazine Ns. in cooling pan
Weight of Juice .. .. Mds.	12·5	12·5
Raw Juice:—		
Brix	15·63	15·63
Pol	11·93	11·93
Purity	76·33	76·33
pH	5·5	5·5
**Colour:—*		
Yellow	10·4	10·4
Red	3·7	3·7
Blue	2·4	2·4
Clear Juice:—		
Brix	15·87	15·97
Pol	12·03	12·09
Purity	75·80	75·71
pH	5·4	5·4
**Colour:—*		
Yellow	10·4	10·4
Red	1·1	1·0
Blue	0·7	0·7
Gur:—		
Brix	96·83	97·27
Pol	64·69	64·97
Purity	66·81	66·79
**Colour:—*		
Yellow	10.4	11·0
Red	2·3	2·5
Blue	0·3	0·2

*By Lovibond Tintometer.

APPENDIX 'C'

Effect of Sodium Bi-sulphite on quality of Gur

Sl. No.	Particulars	Deola	Deola and Sodium-bi-sulphite	Deola and Soda-bi-sulphite	Deola and Soda-bi-sulphite
1	Weight of Juice .. .. Mds.	8·64	8·80	8·40	7·50
2	Weight of clarificants .. .. Lbs.	0·31	0·12	0·15	0·23
3	Weight of clarificant on 100 mds. Juice Lbs.	3·59	1·36	1·79	3·07
4	Raw Juice:—				
	(a) Brix	20·12	19·11	19·11	19·87
	(b) Pol	15·57	15·88	15·88	15·88
	(c) Purity	77·39	83·10	83·10	79·92
	(d) pH	5·5	5·5	5·5	5·5
	*(c) Colour:—				
	(i) Yellow	30·5	30·5	3 ·5	30·2
	(ii) Red	18·9	19·1	19·1	19·4
	(iii) Blue	6·6	6·4	6·4	6·2
5	Clarified Juice:—				
	(a) Brix	20·54	20·17	20·70	20·40
	(b) Pol	15·84	16·69	17·03	15·64
	(c) Purity	77·12	82·75	82·27	76·67
	(d) pH	5·4	5·4	5·4	5·3
	*(e) Colour:—				
	(i) Yellow	19·1	18·6	18·9	18·6
	(ii) Red	6·8	6·8	6·3	6·4
	(iii) Blue	3·1	3·0	3·1	2·9
	(f) Colour % removed	48·22	49·29	49·46	50·00
6	*Gur*:—				
	(a) Brix	97·06	96·82	97·14	96·92
	(b) Pol	68·16	73·27	73·02	67·71
	(c) Purity	70·22	75·68	75·17	69·86
	*(d) Colour:— (13% solution)				
	(i) Yellow	16·9	16·8	16·8	1 ·
	(ii) Red	5·2	5·1	5·1	5·1
	(iii) Blue	2·2	1·8	1·7	1·6

*By Lovibond Tintometer

A NOTE ON THE HYDRATION OF CANE SHEATHS AS AN INDICATOR OF MATURITY

By

V. Ranganathan

(Central Sugarcane Research Station, Cuddalore, Madras)

THOUGH much work has been done on hydration of cane sheaths by Clements *et al.* in Hawaii, and many other workers, no work has so far been done in this state, to test the suitability of hydration level of cane sheaths as an indicator of ripeness of cane for this tract. Clements has studied the internal water relations of various tissues, and working out many correlations, recognised the water level of elongating leaf sheaths to represent the internal water relations. Clements *et al.* (1948) using the water level of elongating leaf sheaths as moisture index have fixed 73-74 per cent moisture level in elongating leaf sheaths as an index of ripeness of sugarcane. They also developed a system of applying water which consists in bringing down the moisture level to 74 per cent and thereby regulating the ripeness of cane. Differences in Sucrose content due to different Nitrogen doses, and also due to various cultural treatments were attributed to the difference in the hydration levels by various authors.

It was also pointed out by Parthasarathy and Rama Rao (1950) that early varieties recorded lower hydration early in season, while late varieties maintain them. Early varieties under similar conditions record lower hydration level than late varieties.

Material and Methods

The hydration of elongating leaf sheaths were determined for 14 agronomically important varieties, from December to May at monthly intervals. Refractometer brix were recorded from January to May. The results of analysis are given in the Tables I and II.

Results and Discussion

The data indicate that all varieties record a decrease in sheath hydration level in the post-monsoon period, the fall in hydration level being early in early varieties and late for late varieties. For the same

Table I

Sheath hydration percentages. Early and mid series. Date of planting: March 1957

Sl. No.	Experiment	Variety	Sheath hydration						Refractometer Brix				
			6-12-57	7-1-58	9-2-58	6-3-58	7-4-58	6-5-58	7-1-58	9-2-58	6-3-58	7-4-58	6-5-58
1	Maturity observation plot of early varieties	Co. 419	449	349	352	265	243	289	16·5	18·0	19·0	21·1	20·2
2		Co. 449	280	232	181	195	199	226	18·0	19·0	19·4	20·6	21·1
3		Co. 527	304	286	284	242	195	224	13·0	17·5	19·7	20·4	20·4
4		Co. 658	359	286	281	272	286	269	19·6	20·6	22·1	22·3	22·3
5		Co. 729	307	293	249	258	182	293	20·6	20·9	21·4	22·3	22·3
6		Co. 785	311	255	244	236	211	239	20·3	21·0	22·1	22·9	22·9
7		Co. 793	316	293	246	227	176	240	19·5	21·1	23·6	24·0	24·0
8	Preliminary yield trial mid series	Poj. 3016	420	388	288	280	..	..	17·6	20·6	22·8	..	..
		H. 32/8560	289	279	256	217	..	..	19·6	21·2	21·9	..	..
		Co. 1001	279	279	283	246	..	..	18·7	18·8	21·2	..	..

TABLE II

Sheath hydration percentages. Late series. Date of planting: May 1957

Sl. No.	Experiment	Varieties	Sheath hydration						Refractometer Brix				
			6-12-57	7-1-58	9-2-58	6-3-58	7-4-58	6-5-58	7-1-58	9-2-58	6-3-58	7-4-58	7-5-58
1	Maturity observation plot of late series	Co. 419	..	428	355	342	288	278	13·2	15·9	19·5	21·5	19·0
2		Co. 449	..	305	279	251	194	209	17·6	17·4	21·7	22·2	20·1
3		Co. 785	..	291	313	258	213	241	16·6	18·5	21·4	21·6	21·2
4		Co. 750	360	304	257	248	247	231	16·3	19·8	21·6	19·7	22·4
5		Co. 810	371	356	287	253	203	258	15·1	19·9	22·9	24·8	20·8
6		Co. 853	364	275	238	236	179	221	15·3	20·6	21·5	21·4	21·1
7		Co. 961	419	385	342	302	284	333	13·6	16·2	20·8	22·1	16·5

variety, the hydration was more for late planted crop than for early planted crop, in the early part of the season, but the differences were narrowed down as the season advanced.

Most of the varieties recorded a maximum increase in Brix at a hydration level between 250-300, and all the varieties reached a hydration level below 280, before harvest. Probably the 74 per cent moisture index (280 per cent hydration) of Clements holds good for this tract. There is also an indication of late varieties capable of ripening at a much higher level.

During the ripening phase, the moisture level was fairly maintained round about ripening index. Significant correlation was found between hydration level and refractometer Brix of the standing canes. As the Brix for a particular hydration level may vary depending upon the period maintained at that hydration level, it has been found difficult to predict the Brix from the hydration level. Only Co. 658 from early series has maintained a uniform hydration (about 280 per cent) throughout the season; and it may indicate the keeping quality of cane in the field.

Earliness or lateness of variety, was best indicated by hydration level in the month of February, the early varieties recording hydration level about 250 per cent, mid varieties about 280 per cent, and late varieties above 300 per cent. In March and April, the hydration level falls, and the differences due to various times of plantings and varieties were considerably narrowed down. In May, most of the varieties registered higher hydration, with their refractometer Brix decreasing. This suggests deterioration which affects the ratio of carbohydrate to protein derivatives which are considered to have some relation with internal water relations.

CONCLUSIONS

1. It seems from these observations that the varieties attain a hydration level of about 280 per cent at ripening, and by adjusting the irrigations in such a way to maintain sheath hydration level of about 280 per cent for two months before harvest, it is possible to ripen the crop to get maximum sugar per acre.
2. Sheath hydration studies also gives information about earliness or lateness of variety.

ACKNOWLEDGEMENTS

I greatly acknowledge the help and encouragement given by Sri D. John Dorairaj, Assistant Agricul-cultural Chemist, and Sri C. R. Thiruvengadam, Sugarcane Specialist (Incharge) during the course of this study. I also wish to thank the Indian Central Sugarcane Committee which is partly financing the scheme.

REFERENCES

Parthasarathy, S. V. and Rama Rao, N. V. (1950). Tissue moisture and its relation to Sugarcane ripening. *Proc. 1st Bien. Conf. of Sug.cane Res. Workers,* Coimbatore—January, 1951.

Van Dilliewijn (1952). Botany of Sugarcane, 1951.

Research Notes

Removal of late tillers of sugarcane and its effect on the quality and tonnage of the crop

AN investigation was conducted to study the effect of removal of late tillers, which fail to develop into millable canes on the yield and sucrose content of two varieties of sugarcane viz. Co. 453 and B.O. 22 at Chawki farm in Saran District (Bihar).

The design of the experiment was a single randomised block with 6 replicates. Each block consisted of 5 plots designed as September series, October series, November series, December series and Control. In each of the first four series tillers were removed in the first week of the corresponding month and subsequently in first week of each month till December. Thus tillers were removed four times in September series, thrice in October series, twice in November series and only once in December while the control was left as such. The net plot size was 1/40th of an acre. Weight of the removed tillers was recorded. Samples taken from each treatment variety-wise, were dried and analysed. The crop was harvested in fourth week of January, 1955.

The results obtained are presented in the following two tables. Table I shows the cane yield, sucrose percentage and weight of tillers removed while Table II shows chemical analysis of tillers removed in different months.

TABLE I

Cane yield in lbs., sucrose percentage and weight of tillers removed, 1955

	Variety	Sept. series	Oct. series	Nov. series	Dec. series	Control	Mean	C.D. at 5%
Yield in lbs.	Co. 453	1081·6	1036·6	1071·6	986·6	985·0	1021·6	..
	Bo. 22	692·6	640·0	660·0	652·6	627·6	654·6	..
Sucrose percentage	Co. 453	17·85	17·57	17·50	17·12	17·39	17·49	..
	Bo. 22	15·57	15·33	14·57	15·74	15·15	15·40	..
Weight of tillers removed in lbs.	Co. 453	45·9	31·3	28·6	12·8	..	29·6	11·1
	Bo. 22	99·1	90·3	90·6	40·75	..	80·2	8·02

TABLE II

Chemical analysis of tillers removed in different months

Details of tillers removed in the week	Co. 455 crude protein %	P_2O_5	BO. 22 crude protein %	P_2O_5
1st week of September, 1954	7·29	0·99	8·4	0·93
1st week of October, 1954	8·16	0·43	7·48	0·88
1st week of November, 1954	10·59	0·59	8·26	0·51
1st week of December, 1954	8·19	0·56	10·54	0·64

A perusal of the above data shows that the yields of both the varieties were increased about 9 per cent by removal of late tillers in September. Similar increase though of lower order were effected in other series. Sucrose content was also improved though not so distinctly as the yield except in November series in B.O. 22 and in December series in case of Co. 453. Highest protein content was shown by tillers removed in November in Co. 453 and in December in B.O. 22. Phosphate content was highest in September series in both the varieties.

Removal of late tillers in Sugarcane has often been suggested as useful agronomic practice contributing to increased yields. This study has indicated that it not only increases yield but also helps in improving the quality of the cane. Under the conditions existing in this area it is found that tillers may be removed from September onwards until November advantageously. The beneficial effects of removal of late tillers may be attributed to withdrawal of competition between pre-monsoon and post-monsoon (late) tillers resulting into availability of more nutrition to early tillers. (C. Thakur and A. Misra, Sugarcane Research Institute, Pusa, Bihar).

Occurrence of Red Stripe Disease in Bihar

IN general, the disease is seldom noticed in the State although in certain years, in localised areas, it may occur in an epidemic form, especially on varieties B.O. 10, B.O. 17 and Co. 419. During 1957, red stripe epidemic was observed in severe form in B.O. 10 in the reserved area of North Bihar Sugar Mills, Bagaha in Champaran district. It was noted at other places also as given in Table I. Normally the symptoms are confined to the leaves and leaf sheaths but in severe infections the disease affects the young leaves of the spindle and spreads one to two internodes downwards in which case the affected cane tops dry up. On splitting, the affected canes give out pungent smell. The parenchymatous cells are disorganised and become dark brown in colour. Sometimes when the disease is associated with top rot the damage is more severe than that caused by either of them attacking singly. In Bagaha factory area further spread of the disease on certain varieties (Table I) was checked by adopting timely control measures like clipping of the affected leaves and removal of the affected stalks. The cost for these operations came to Rs. 2·34 per acre. At other places the disease subsided after heavy rains. (R. K. Singh and H. C. Prasad, Sugarcane Research Institute, Pusa, Bihar).

TABLE I

Incidence of Red Stripe Disease in Bihar During 1957

Date of observation	District	Place	Variety	Incidence
23/25-4-57	Champaran	Majhaulia	B.O. 17 (Ratoon)	Trace
14/28-7-57	-do-	Bagaha	B.O. 3 (Plant cane)	,,
		-do-	B.O. 10 (Plant cane)	Trace to heavy*
	..	-do-	B.O. 17 (Plant cane)	,,
	..	-do-	Co. S. 443 (Plant cane)	,,
	..	-do-	Co. 453 (Plant cane)	Trace to mild
22-8-1957	-do-	Motihari	Co. S. 416 (Plant cane)	,,
24/26-8-1957	-do-	Narkatiaganj	BO. 10 (Plant cane)	Moderate
17/19-7-1957	Saran	Hathua	Co. S. 416 (Plant cane)	Trace
12/14-7-1957	Monghyr	Haveli-Kharagpur	B.O. 17 (Plant cane)	,,
		-do-	Co. 419 (Plant cane)	,,
8/10-7-1957	Shahabad	Dehri-on-Sone	Co. 419 (Plant cane)	Mild
		-do-	B.O. 17 (Ratoon)	Trace

*Above 25 %

Miscellany

Seminar at the Sugarcane Breeding Institute, Coimbatore

THE fifth seminar of the scientific staff of Sugarcane Breeding Institute Coimbatore, met on 7-5-1959. The Director, Dr. N. R. Bhat, presided. Shri K. V. Srinivasan, Mycologist, spoke on 'Certain trends in red-rot investigations'. He traced briefly the history of the disease both abroad and in India.

Discussing the question of strains of the pathogen, Shri Srinivasan observed that one of the distinguishing characteristics of strains was the difference in their stability and that only the more stable and virulent strains could bring about an epiphytotic. He next dealt with modes of infection in red rot and the characteristics of an epiphytotic. The speaker thought that current conceptions did not sufficiently explain how epiphytotics involving one or more new strains suddenly erupted over a vast area almost simultaneously. Shri Srinivasan then spoke of the observations made in Louisiana and said that dormant infections in the leaf scars and bud scales might possibly contribute to the building up of a pathogenic flora over a period of years and to its dissemination over an area and where favourable environmental conditions occurred, an epiphytotic outbreak might be expected. He mentioned that varieties differ in their susceptibility to build up latent infections and suggested that this aspect needed investigation at the Sugarcane Breeding Institute.

Several members of the Institute took part in the discussion that followed. Summing up, the Director suggested that investigations be taken up on the mode of infection of the leaf scars and bud scales and the mode of transmission of such infections from one generation to the next. (Sugarcane Breeding Institute, Coimbatore, Madras.)

A Short Note on the Progress of Sugarcane Development work in West Bengal

SUGARCANE accounts for only 1/250th of the net cultivated area in West Bengal and the acreage under sugarcane in this State (Approximately 60,000 acres) constitutes an insignificant proportion of the total cane acreage in this country. The partition of the country affected the cultivation of sugarcane and the sugar industry in general, adversely. Prior to partition, there were about 3·5 lakh acres under sugarcane in Bengal with seven sugar mills. At the moment, there is only one mill functioning in the State and another one in making. Considering the excellent natural growing conditions for the cane crop and the high yield which can be obtained by intensive developmental work, there is a good scope of expansion of sugar industry in this State, and efforts made in this direction are summarised below.

The scheme for the development of sugarcane cultivation in West Bengal under the aegis of Indian Central Sugarcane Committee since its inception in 1950 has been aiming at a substantial increase in the production of sugarcane in this State without much encroachment on the areas under other crops. To achieve this end, the working plan included in production of improved varieties and their quickest multiplication and distribution, adoption of proper manurial schedule and cultural practices and their dissemination through occular demonstration, survey of sugarcane crop with respect to area and production in different districts, plant protection, publicity and propaganda.

The achievements of the scheme during the first five year plan period have been set out in the Table below:

Achievements of sugarcane development during 1950-1956

	1950–51	1951–52	1952–53	1953–54	1954–55	1955–56
Area under Sugarcane (acres)	52,500	46,300	52,300	46,900	56,800	60,900
Total production of Sugarcane in the State (tons)	8,55,900	8,19,800	10,38,300	6,50,200	11,93,100	12,89,500
Average yield per acre (mds.)	442·93	481·97	540·40	377·38	517·71	576·38
Total quantity of sugarcane crushed in sugar mill (Mds.)	8,72,097	17,94,769	21,01,143	13,98,985	23,45,409	26,02,899
Total quantity of sugar produced (Mds.) ..	97,918	1,95,377	2,17,915	1,39,700	2,57,705	2,72,253

From the Table, it is evident that there is a considerable scope for stepping up the production of sugarcane in the state, substantially. While the acreage in 1955-56 has increased by about 8,000 acres over 1950-51 figure, production has also been pushed up to the extent of 50 per cent and the per acre out-turn has increased by 130 mds. The result of demonstration work has indicated that it is possible to obtain yield as high as 60 tons per acre with a 12 month's variety which can favourably compare with the yield obtained in Peninsular India as well as that of other sugarcane growing countries. As a result of large scale distribution of better varieties of seed cane carried out in the mill-zone, it has been possible to crush nearly 27,00,000 mds. of sugarcane in the sugar mill, nearly four times the quantity of cane crushed in 1950-51 and the extra sugar produced yielded an additional revenue of about 8 lakh rupees.

The quantity of sugarcane now being grown in the State, the present yield per acre and the working results of the existing sugar mill leave no doubt that there are great possibilities for the development of sugar industry in West Bengal. The annual consumption of sugar in this State is approximately $1\frac{1}{2}$ lakh tons as compared to her internal production of nearly 10,000 tons. The wide disparity offers prospects for setting up a number of sugar mills in the State.

The Second Five Year Plan envisages continuance of action in the field of sugarcane development in this State and to increase the acre yield by intensive cultivation and as a result of that total production will increase. Sugarcane being a long term crop requires an assured disposal arrangement so that the growers can be inspired to produce more better quality cane by actively participating in development programme implemented through the sugarcane development scheme. Naturally necessity of a number of Sugar mills cannot be over-emphasised in the interest of successful implementation of the development programme.—(Sugarcane Specialist, West Bengal, Calcutta).

Book Review

"REGULATION of Sugarcane supplies to Factories in India and other sugarcane growing countries" By M. Lakshmi Kantham Assistant Agronomist, Sugarcane Research Station, Anakapalle—published by Indian Central Sugarcane Committee, 19-20, Rohtak Road, New Delhi 5 (1959).

66 Pages; $9\frac{1}{2}'' \times 6\frac{1}{2}''$; Rs. 1·50 (Postage and Packing extra).

This book presents a detailed version of particulars in connection with the regulation of cane supplied to the sugar factories on the basis of information and other authentic data collected by the author from the important sugarcane producing states in the country as also from some major Cane growing countries of the world. The book has been divided into three parts. The First and Second parts deal with the Cane supplies in India and other countries respectively. The third part gives general recommendations namely Demarcation of Areas, Registration of Cane supply quotas, Prohibition of certain agricultural practices, Harvest control, Cane price and its payment etc.

On the whole this moderately priced publication would prove useful to all those connected with the varied aspects of sugarcane and sugar industry at home and abroad.—V. P. S.

AGRICULTURAL RESEARCH IN INDIA—INSTITUTES AND ORGANIZATIONS

By M. S. Randhawa, D.Sc., I.C.S., Vice-President, Indian Council of Agricultural Research, New Delhi. 450 pages; 79 plates; 10″×8¼″; Rs. 20·00/$ 6.00/Sh. 40. (Postage & Packing Rs. 5·00 extra).

Here in one volume is presented a connected account of all the agricultural research institutions and organizations in this country. Written by the author of the well-known book, "FLOWERING TREES IN INDIA", this book gives details of all research schemes sponsored by various agricultural organizations in India. It also provides exhaustive information about the functions and set-up of various agencies connected with agriculture, animal husbandry and allied subjects. The book is well produced and contains a large number of informative maps, charts and other illustrations and will be found useful to research workers, libraries, Parliamentarians, Administrators, Trade Organizations and others concerned with the agricultural research and development.

STATISTICAL METHODS FOR AGRICULTURAL WORKERS

(Second Edition)

By V. G. Panse, Statistical Adviser, Indian Council of Agricultural Research, New Delhi and P. V. Sukhatme, Chief, Statistics Branch, F.A.O. Rome.

361 pages; 9¾″×6¾″; Rs. 15·00/$ 5.00/Sh. 36. (Postage etc. Rs. 3·00 extra).

This book, by two of the foremost authorities on the subject, presents the general statistical principles as they work out in agriculture. It gives the students of agriculture a good fundamental knowledge about the statistical methods and design of experiments applied to agricultural research. Divided into two parts, the book contains sixteen chapters. It is a highly useful text book for students of agricultural and biological science, and a valuable work of reference to the research workers.

CONTENTS.

PART I: STATISTICAL METHODS.

Frequency Distributions; The Normal and Binomial Distributions; Sampling Method and Standard Errors; Tests of Significance of Means and Their Differences; the X2 Test and Estimation of Linkage; Correlation and Regression.

PART II: DESIGN OF EXPERIMENTS.

Principles of Field Experimentation; Randomized Blocks and Latin Square; Factorial Experiments; Confounding; Split-Plot and Strip-Plot Designs; Analysis of Covariance and Missing Plot Technique; Designs for Plant Breeding Trials; Groups of Experiments; Practical Considerations in Field Experimentation; Experiments in Cultivators' Fields.

Indian Journal of Sugarcane Research and Development

Advice to Contributors

1. Papers for publication in the Journal should be sent by name to Shri P. P. Chandra, Secretary, Indian Central Sugarcane Committee, who is also the Editor of the Journal.

2. Articles from research workers whether employed in the Government or in Universities, or elsewhere, should be submitted through the head of the research institute where the work has been carried out.

3. Papers submitted for publication in the *Indian Journal of Sugarcane Research and Development* would be presumed to have been offered simultaneously to no other journal for publication.

4. Papers must be sent typed, and *in duplicate* on one side of the sheet only, in double spacing, leaving enough margin on all sides for corrections and instructions to the press.

5. The name or names of authors or author of the papers submitted for publication must be followed by some appropriate indication of address, such as official designation, institution, place, name etc.

6. Indiscriminate underlining of headings and use of fullstops and other punctuation marks should be avoided.

7. Literature should be cited in the text by giving the name(s) of the author(s) and year of publication in brackets, or where the name(s) occur in the text, by giving the year only. It should be listed at the end of the paper in the alphabetical order of the authors' names, followed by the year, name of the Journal (underlined and abbreviated according to the latest edition of the "World List of Scientific Periodicals"), volume number (doubly underlined), part of the volume, if necessary, in brackets and page reference. Example: Hardy, J. E. (1939). *Bull. ent. Res.*, **30**(2): 237-246. An exception may be made in the case of 'Short Notes', wherein references may be given in foot-notes or in the text but these must be in the style described above. Where a paper submitted for publication is one in a series, information regarding the other papers of the series should always be given in a foot note on the first page.

8. If a paper under reference has not been seen in original it is safe to state 'original not seen'. *Sources of information should be specifically acknowledged.*

9. Illustrations must bear on their reverse side the name of the author and a short title of the paper they are meant to illustrate. They should be capable of suffering reduction on reproduction, due allowances being made for thickness of lines, size of letterings, etc., in the process. Numbering of plates and figures should be done in pencil. Papers accompanied by illustrations should be so packed as to avoid folding of the illustrations or other damage to them. Legends must be written in the form in which they are to be printed below the illustrations. Photographic prints for reduction should be unmounted, black and white and on glossy surface paper or line work. The size of a plate after reduction should not exceed 8·5 × 5·5 sq. inches.

10. Common Indian or English names of plants and insects should be followed by their scientific names on their first occurrence in the text. Scientific names of insects and plants and their Indian names, if stated, should be invariably underlined in the text.

11. Names of orders, superfamilies, families and genera of insects and plants, wherever occurring, must begin with a capital letter, and common Indian or English names of insects and plants with a small letter, e.g. kutra, neem, codling, moth, mango.

12. Each paper exceeding about 2,000 words should be accompanied by a short abstract of about 300 words which should be clear and self-contained.

13. Wherever possible concrete recommendations based on the results of research reported, should also be given.

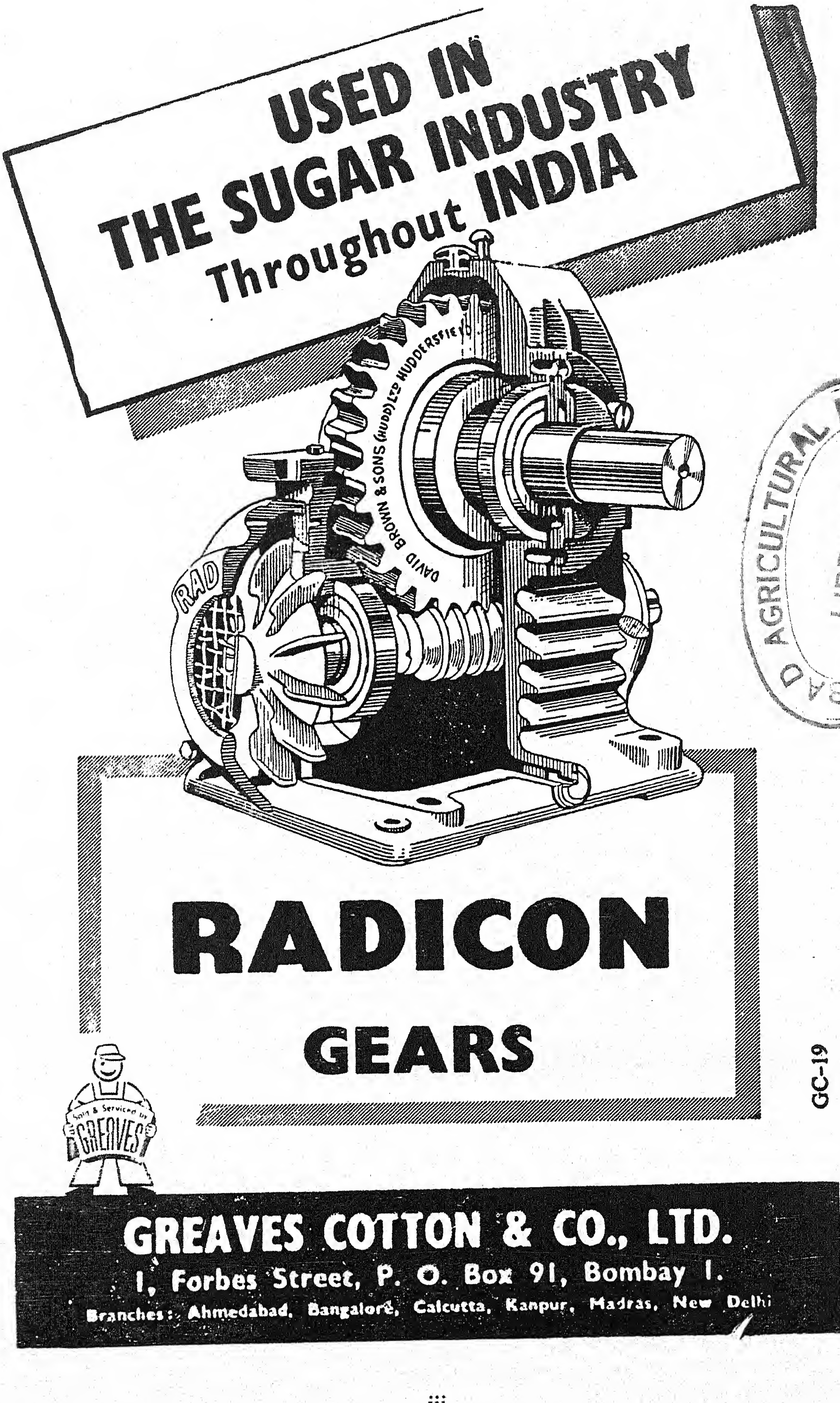
14. Proof copies sent to the authors for corrections should be returned to the Secretary, Indian Central Sugarcane Committee, immediately after correction. The corrections must be made very clearly and legibly in ink. Extensive corrections or additions at the proof stage will not be allowed.

15. Authors shall receive 50 reprints of their papers free. These will be distributed equally among the authors in the case of papers published under joint authorship. Additional copies can be supplied on payment provided the requirements are intimated in advance.

SUGARCANE RESEARCH IN INDIA DURING 1929-54

The Ad-Hoc Expert Sub-Committee of the Indian Central Sugarcane Committee consisting of Sarvashri Lal Singh, N. L. Dutt and K. L. Khanna, after visiting a number of sugarcane research stations in operation in the States and looking through voluminous data collected under the sugarcane research and development schemes, have prepared the Resume of Sugarcane Research in India during 1929-54. It contains in the form of notes the recommendations that have emerged as a result of the research work done under Sugarcane Research Schemes both at the Central and States Institutes, on different aspects of sugarcane research based on the different aspects of sugarcane cultivation. These notes have been arranged accordingly as different chapters e.g., Sugarcane Agronomy, Sugarcane Physiology, Soil Studies etc.

The resume presents not only an All-India picture but important details of studies carried out in the States are also included. The Resume under the title of 'Review on Sugarcane Research in India during 1929-54' appeared in a serial form in the Indian Journal of Sugarcane Research & Development and has now been compiled as a single book with graphic and illustrated cover in coloured design. The price per copy (exclusive of postage) is Rs. 5/-...... and is available from the Secretary, Indian Central Sugarcane Committee, 19-20, Rohtak Road, New Delhi-5.


USED IN
THE SUGAR INDUSTRY
Throughout INDIA
DAVID BROWN & SONS (HUDD) LTD HUDDERSFIELD
RAD
RADICON
GEARS
Sold & Serviced by
GREAVES
GREAVES COTTON & CO., LTD.
1, Forbes Street, P. O. Box 91, Bombay 1.
Branches: Ahmedabad, Bangalore, Calcutta, Kanpur, Madras, New Delhi
GC-19

STUDIES ON THE RELATIVE EFFICIENCY AND EFFECT OF CERTAIN NITROGENOUS FERTILIZERS ON SOIL COMPOSITION, JUICE QUALITY AND YIELD OF SUGARCANE

By

RANBIR SINGH KANWAR and HARDYAL SINGH

(Sugarcane Research Station, Jullundur, Punjab)

INTRODUCTION

HEAVY dressings of nitrogenous fertilizers are required for obtaining high yields of sugarcane. A number of nitrogenous fertilizers are available in the market, and there is a considerable variation in their composition, and so their effect on soil composition, juice quality and yield may also vary. With a view to studying the relative efficiency of sulphate of ammonia—the most widely used fertilizer, chilian nitrate and groundnut cake, studies were undertaken at the Sugarcane Research Station, Jullundur. Rege (1939) reported soda nitrate to be the best fertilizer. In U.P. experiments conducted at Partap Garh Farms (1935) did not show that any one of sulphate of ammonia, sodium nitrate or potassium nitrate was distinctly superior to the other. Similarly, at Padegaon (Bombay) in 1939 application of ammonium sulphate, sodium nitrate, potassium nitrate and calcium cyanide did not result in significant differences in cane yield. Gahlot (1954) arrived at the same conclusion. Khan, Misra and Alam (1954) observed that calcium nitrate was a better fertilizer than chilian nitrate and ammonium sulphate.

MATERIAL AND METHOD

The experiment was run for a period for two years. During the first year (1954-55) the experiment was laid out according to the split plot design with the basal dressings as main plots and fertilizers into doses as sub-plots. The details of treatments are as under.

D_0—No basal dressing.

D_1—Lime at 1,100 lbs. per acre.

D_2—Farmyard Manure to provide 50 per cent of total nitrogen and 50 per cent nitrogen to sub-plots in different fertilizers.

Sub-plots:— Ammonium Sulphate × 100 lbs. nitrogen.
Chilian Nitrate 200 lbs. nitrogen.

During the second year (1955-56), however, the experiment was modified and basal dressing of lime was eliminated. The layout was randomized block design with the following treatments:—

Form of Nitrogen	*Doses*
M_1—Groundnut cake	
M_2—Ammonium Sulphate	
M_3—Chilian Nitrate	
M_4—Groundnut cake and Farmyard Manure on 50 : 50 nitrogen basis	D_1—100 lbs. Nitrogen.
M_5—Ammonium Sulphate and Farmyard Manure on 50:50 nitrogen basis	D_2—200 lbs. Nitrogen.
M_6—Chilian Nitrate and Farmyard Manure on 50 : 50 nitrogen basis.	plus Control.

Farmyard Manure, groundnut cake and Lime were applied at planting time and ammonium sulphate and chilian nitrate in two equal doses in June and July. Soil and leaf samples were taken periodically and analysed. Cane samples were analysed for sucrose and purity co-efficient at monthly intervals; cane yield having been recorded at the harvest time.

EXPERIMENTAL RESULTS

In order to see the uptake of various nutrients by the sugarcane plants, leaf samples taken periodically were analysed and the results are given in Table I.

TABLE I

Leaf analysis (1954-55) *percentage on dry matter*

	July					At harvest (May, 1955)				
	N	Ash	P_2O_5	Ca.	K_2O	N	Ash	P_2O_5	Ca.	K_2O
T_1—No basal dressing plus 100 lbs. N as A/S	1·68	8·09	0·50	0·63	1·71	0·72	12·50	0·26	0·58	1·01
T_2—No basal dressing plus 100 lbs. N as C/N	1·69	7·55	0·49	0·63	1·61	0·83	11·70	0·24	0·58	0·85
T_3—No basal dressing plus 200 lbs. N as A/S	1·72	7·57	0·49	0·64	1·68	0·75	12·43	0·22	0·55	0·88
T_4—No basal dressing plus 200 lbs. N as C/N	1·95	6·28	0·50	0·65	1·42	0·85	9·70	0·25	0·50	1·20
T_5—Control..	1·46	8·30	0·49	0·58	1·74	0·67	13·58	0·23	0·62	1·15
T_6—Basal dressing of 1100 lbs. lime P.A. plus 100 lbs. N as A/S ..	1·46	7·52	0·47	0·71	1·63	0·71	12·02	0·24	0·60	0·78
T_7—Basal dressing of 1100 lbs. Lime P.A. plus 100 lbs. N as C/N ..	1·61	7·45	0·39	0·71	1·76	0·80	11·05	0·25	0·56	0·86
T_8—Basal dressing of 1100 lbs. Lime P.A. plus 200 lbs. N as A/S ..	1·54	7·25	0·47	0·69	1·64	0·85	12·67	0·26	0·61	0·81
T_9—Basal dressing of 1100 lbs. Lime P.A. plus 200 lbs. N as C/N ..	1·72	6·08	0·46	0·72	1·83	0·80	10·60	0·29	0·50	1·11
T_{10}—Basal dressing of 1100 lbs. Lime P.A. plus no nitrogen ..	1·18	8·32	0·47	0·67	1·85	0·64	10·91	0·25	0·57	1·08
T_{11}—Basal dressing of F.Y.M. to supply 50 lbs. N plus 50 lbs. N as A/S	1·40	6·84	0·47	0·62	1·56	0·67	11·16	0·25	0·52	1·05
T_{12}—Basal dressing of F.Y.M. to supply 50 lbs. N plus 50 lbs. N as C/N	1·47	7·63	0·48	0·63	1·99	0·72	12·38	0·27	0·56	1·08
T_{13}—Basal dressing of F.Y.M. to supply 100 lbs. N plus 100 lbs. N as A/S	1·58	8·25	0·47	0·67	1·83	0·86	9·82	0·30	0·47	1·16
T_{14}—Basal dressing of F.Y.M. to supply 100 lbs. N plus 100 lbs. N as C/N	1·68	8·23	0·49	0·65	1·58	0·81	11·00	0·30	0·57	0·81
T_{15}—No basal dressing and no nitrogen	..	..	..	..	..	..	..	..	..	..

1955-56

Percentage on dry matter

	July					October					January				
	N	Ash	P_2O_5	Ca	K_2O	N	Ash	P_2O_5	Ca	K_2O	N	Ash	P_2O_5	Ca	K_2O
T_1—100 lbs. N. as G.N.C.	1·69	8·44	0·61	0·44	1·61	1·33	8·07	0·54	0·32	1·58	1·27	11·52	0·49	0·31	1·33
T_2—200 lbs. N. as G.N.C.	1·76	8·54	0·63	0·46	1·60	1·51	9·10	0·58	0·37	1·57	1·35	11·45	0·53	0·32	1·32
T_3—100 lbs. N. as A/S	1·69	9·01	0·60	0·46	1·60	1·39	8·86	0·50	0·34	1·49	1·29	11·32	0·49	0·32	1·29
T_4—200 lbs. N. as A/S	1·84	8·88	0·60	0·44	1·56	1·51	8·21	0·53	0·38	1·50	1·32	11·66	0·50	0·33	1·17
T_5—100 lbs. N. as C/N	1·95	8·38	0·60	0·44	1·52	1·31	9·55	0·51	0·32	1·48	1·23	10·27	0·47	0·28	1·47
T_6—200 lbs. N. as C/N	1·97	8·69	0·60	0·45	1·50	1·48	11·16	0·54	0·34	1·40	1·35	11·31	0·53	0·35	1·23
T_7—100 lbs. N. 50% F.Y.M. and 50% as G.N.C.	1·53	9·12	0·60	0·43	1·61	1·37	9·63	0·54	0·35	1·50	1·27	11·43	0·49	0·30	1·35
T_8—200 lbs. N. 50% F.Y.M. and 50% as G.N.C.	1·60	8·51	0·61	0·45	1·60	1·33	9·24	0·56	0·37	1·46	1·31	11·39	0·50	0·32	1·32
T_9—100 lbs. N. 50% F.Y.M. and 50% as A/S	1·72	8·68	0·61	0·44	1·50	1·41	8·54	0·51	0·34	1·52	1·27	11·52	0·51	0·32	1·26
T_{10}—200 lbs. N. 50% F.Y.M. and 50% as A/S	1·76	8·99	0·60	0·45	1·72	1·56	9·77	0·53	0·34	1·52	1·35	11·69	0·50	0·32	1·34
T_{11}—100 lbs. N. 50% F.Y.M. and 50% as C/N	1·65	8·40	0·60	0·43	1·56	1·43	9·57	0·52	0·35	1·42	1·29	10·94	0·48	0·32	1·38
T_{12}—200 lbs. N. 50% F.Y.M. and 50% as C/N	1·79	8·12	0·55	0·44	1·59	1·43	9·86	0·53	0·37	1·40	1·47	11·06	0·51	0·33	1·30
T_{13}—Control.. ..	1·27	8·00	0·54	0·40	1·68	1·30	9·20	0·50	0·32	1·52	1·18	10·97	0·47	0·30	1·52

F.Y.M. represents Farm Yard Manure G.N.C. represents Groundnut Cake
A.S. „ Ammonium Sulphate C.N. „ Chilian Nitrate

The uptake of nitrogen by the sugarcane plant in general was higher under nitrogen application. The absorption of this nutrient was greater in the case of chilian nitrate as compared to ammonium sulphate and groundnut cake, showing thereby ready availability of nitrogen from chilian nitrate. The leaf tissue continued to maintain a higher protein status till the harvest of the crop during 1954-55 but the same was not true in 1955-56 when chilian nitrate showed comparatively better performance than ammonium sulphate and groundnut cake only in the early stages; the differences at later stages being almost negligible. The absorption of nitrogen from 200 lbs. nitrogen dose was found to be more than 100 lbs. nitrogen level. Where nitrogen was supplied half through farmyard manure, the nitrogen absorption was also less than where full dose was applied as inorganic fertilizer. Basal dressing of Lime showed a depressing effect on the nitrogen uptake. Groundnut cake, the organic nitrogenous manure was found to be as efficient a source of nitrogen as the two inorganics.

With nitrogen manuring, the uptake of phosphorus and calcium was considerably increased thus showing that the requirements of sugarcane for these constituents increase in proportion to nitrogen application due to better growth of the plant. The lime content of leaf tissue was also higher where soil was supplied with lime. Lime was also found to decrease the potassium and phosphorus absorption. No consistent differences in the absorption of potassium were noted either with ammonical or nitrate fertilizers.

It was noted that the rate of increase in the absorption of nutrients was more where full dose of nitrogen was applied through manures alone as compared to that in combination with Farmyard Manure and fertilizers on 50:50 nitrogen basis. Chilian nitrate improved the absorption of nitrogen, phosphorus and calcium more than ammonium sulphate and groundnut cake particularly during 1954-55. Due to greater protein synthesis under nitrogen application, the ash content of the leaf tissue was considerably depressed. Compared against one another, ammonium sulphate both at 100 and 200 lbs. nitrogen level recorded higher ash content than the same doses of chilian nitrate.

Soil Analysis

Soil samples taken periodically were analysed for various constituents. The results are presented in Table II.

TABLE II

Soil analysis

1954-55

Treatments	Percentage on air dry soil								
	*Before sowing Sugarcane			July			At harvest May, 1955		
	N.	Ex. Ca m.c./100 gms. soil	Ph.	N.	Ex. Ca m.c./100 gms. soil	Ph.	N.	Ex. Ca m.c./100 gms. soil	Ph.
T_1	0·046	8·6	7·4	0·053	8·3	7·4	0·046	8·2	7·4
T_2	0·046	8·6	7·4	0·053	8·8	7·4	0·041	8·7	7·4
T_3	0·046	8·6	7·4	0·048	8·9	7·3	0·044	8·0	7·2
T_4	0·046	8·6	7·4	0·048	8·8	7·5	0·039	8·0	7·3
T_5	0·046	8·6	7·4	0·055	8·6	7·4	0·035	8·1	7·3
T_6	0·046	8·6	7·4	0·046	8·3	7·5	0·046	8·0	7·5
T_7	0·046	8·6	7·4	0·048	8·1	7·5	0·043	8·0	7·4
T_8	0·046	8·6	7·4	0·048	8·8	7·3	0·043	7·6	7·4
T_9	0·046	8·6	7·4	0·046	8·8	7·5	0·042	8·1	7·4
T_{10}	0·046	8·6	7·4	0·041	8·5	7·5	0·039	8·0	7·4
T_{11}	0·046	8·6	7·4	0·050	8·3	7·4	0·041	8·0	7·3
T_{12}	0·046	8·6	7·4	0·053	8·9	7·4	0·042	8·0	7·4
T_{13}	0·046	8·6	7·4	0·050	8·8	7·4	0·046	8·0	7·4
T_{14}	0·046	8·6	7·4	0·053	9·0	7·3	0·042	7·9	7·3
T_{15}	..	..	..	..	..	..	..	..	..

TABLE II—(*Contd.*)

1955-56

Treatments	July			October			January		
	N.	O.C.	C/N ratio	N.	O.C.	C/N ratio	N.	O.C.	C/N ratio
T_1	0·050	0·298	6·0	0·059	0·330	5·6	0·056	0·258	4·6
T_2	0·052	0·306	5·9	0·064	0·360	5·6	0·050	0·240	4·8
T_3	0·055	0·318	5·8	0·062	0·348	5·6	0·056	0·252	4·5
T_4	0·046	0·288	6·3	0·056	0·324	5·7	0·050	0·306	6·1
T_5	0·055	0·300	5·5	0·063	0·318	5·0	0·047	0·282	6·0
T_6	0·057	0·298	5·2	0·062	0·306	4·9	0·048	0·282	6·0
T_7	0·057	0·316	5·5	0·062	0·324	5·2	0·048	0·258	5·4
T_8	0·062	0·300	4·9	0·060	0·300	5·0	0·053	0·324	6·1
T_9	0·057	0·298	5·2	0·059	0·336	5·6	0·050	0·300	6·0
T_{10}	0·064	0·312	4·9	0·050	0·300	6·0	0·048	0·276	5·7
T_{11}	0·052	0·306	5·9	0·066	0·360	5·5	0·050	0·282	5·6
T_{12}	0·052	0·324	6·2	0·060	0·324	5·4	0·050	0·312	6·2
T_{13}	0·053	0·322	6·0	0·060	0·324	5·4	0·049	0·300	6·1

* Analysis of only one composite sample taken from the whole field.

During 1954-55, none of the treatments showed any appreciable differences as regards exchangeable calcium and Ph value in the soil both in July and at harvest. However, at harvest nitrogen content of the soil in ammonium sulphate treatment was found to be higher than that in the chilian nitrate, indicating thereby that nitrogen from chilian nitrate being more readily available, was taken up by the plants leaving comparatively less residual nitrogen at the time of harvest. Soil analysis during 1955-56 did not reveal any differences in the nitrogen and organic carbon contents of the soil. Farmyard Manure and groundnut cake slightly improved the organic carbon status of the soil.

JUICE QUALITY

Cane samples taken at monthly intervals were analysed for sucrose and purity co-efficient and the figures are given in Table III.

Application of nitrogen generally delayed the maturity of cane irrespective of the form of its application in the early part of the season. Such differences, however, narrowed down with advance in the season. During the earlier stages, ammonium sulphate both at 100 and 200 lbs. nitrogen level was found to delay the maturity more than chilian nitrate and groundnut cake. Quicker availability of nitrogerr from chilian nitrate and its rapid absorption by the sugarcane crop compared to delayed availability from ammonium sulphate appears to be the cause of difference in juice quality. Liming did not affect the juice quality either way.

CANE YIELD

The yield differences in the case of different forms of nitrogen were non-significant during both the years of experiment. Although the absorption of nitrogen under chilian nitrate was higher, this had no beneficial effect on the final yield of cane. In the case of basal dressings also the yield differences were non-significant. With regard to doses of nitrogen, differences between 100 and 200 lbs. nitrogen were non-significant but these were in favour of 200 lbs. dose during the year 1955-56. The leaf tissue also contained a higher nitrogen content in case of 200 lbs. nitrogen. Nitrogen doses gave significantly higher yield than no nitrogen. The absorption of nitrogen was also similar, it being higher under nitrogen application. During 1955-56, nitrogen in ammonium sulphate gave higher yield than other treatments. Barring combination of farmyard manure with ammonium sulphate which gave the second best cane yield during 1955-56, its

TABLE III

1954-55

	November		December		January		February		March	
	Suc.	Pty.	Suc.	Pty.	Suc.	Pty.	Suc.	Pty.	Suc.	Pty.
T_1 ..	7·0	53·8	9·2	65·0	10·5	64·5	11·6	70·6	12·8	75·4
T_2 ..	7·6	56·3	9·9	66·0	10·9	65·6	12·4	73·1	12·4	76·2
T_3 ..	6·4	54·6	9·8	67·7	9·6	61·3	9·8	62·0	11·9	71·8
T_4 ..	8·1	59·6	10·5	69·6	11·5	67·8	10·2	66·7	11·6	76·7
T_5 ..	10·0	66·6	12·4	76·1	12·2	70·8	13·3	75·3	14·2	77·9
T_6 ..	7·0	54·3	8·6	61·2	9·6	61·6	11·7	70·3	12·4	76·7
T_7 ..	7·5	55·5	11·8	72·5	9·8	60·5	11·7	70·1	12·8	75·6
T_8 ..	7·3	53·3	8·6	61·6	9·7	60·9	10·0	62·9	11·7	72·
T_9 ..	7·4	55·6	10·1	62·0	9·7	58·5	9·5	61·4	12·5	77·3
T_{10} ..	9·3	63·2	12·7	75·5	8·9	58·2	13·1	74·5	14·6	78·8
T_{11} ..	8·7	60·0	11·6	72·9	13·3	75·7	12·7	73·6	13·1	73·0
T_{12} ..	..	..	11·7	74·0	10·5	69·0	12·4	73·1	14·0	78·0
T_{13} ..	..	..	9·9	68·3	12·4	73·6	11·7	70·8	13·1	78·6
T_{14} ..	..	..	11·8	75·4	11·8	73·0	12·9	73·4	12·2	71·9
T_{15} ..	..	..	..	..	..	..	..	..	..	..

1955–56

	November		December		January		February		March	
	Suc.	Pty.	Suc.	Pty.	Suc.	Pty.	Suc.	Pty.	Suc.	Pty.
T_1 ..	11·6	71·6	12·8	76·1	13·6	83·9	14·0	80·8	..	..
T_2 ..	11·5	71·4	13·8	82·4	14·3	86·4	14·4	84·9	..	..
T_3 ..	10·1	67·6	14·3	81·0	14·1	85·8	14·3	85·1	..	..
T_4 ..	9·1	62·5	11·6	73·8	13·8	84·9	13·5	82·5	..	..
T_5 ..	11·6	73·0	12·8	76·1	13·9	85·2	15·9	88·5	..	..
T_6 ..	11·3	71·2	12·9	77·4	13·7	85·1	14·2	82·2	..	..
T_7 ..	11·0	72·0	13·0	77·3	13·8	85·4	15·3	89·2	..	..
T_8 ..	11·5	72·6	13·8	80·1	13·7	88·0	15·6	89·2	..	..
T_9 ..	10·1	68·3	13·0	78·8	13·3	80·8	13·7	83·5	..	..
T_{10} ..	10·5	70·8	12·5	76·5	13·0	83·3	14·5	89·4	..	..
T_{11} ..	10·7	69·3	14·2	80·9	13·8	83·0	14·3	84·0	..	..
T_{12} ..	10·3	69·8	12·7	76·0	13·7	82·9	14·3	83·4	..	..
T_{13} ..	13·6	77·4	13·9	80·3	14·4	86·6	15·1	83·8	..	..

combination with groundnut cake and chilian nitrate proved less effective in influencing cane yield compared to the same doses of nitrogen applied through fertilizers.

The results in respect of cane yield are at variance to those reported by Rege (1939) from Risalewala (Pakistan) where chilian nitrate was found to be the best fertilizer among the inorganic fertilizers. However,

TABLE IV

Yield of stripped cane in mds. per acre

1954-55

Treatments	D_0	D_1	D_2	Mean
T_1—A.S. 100 lbs. N.	838·7	855·7	775·5	823·3
T_2—C.N. 100 lbs. N.	833·0	868·2	830·2	843·8
T_3—A.S. 200 lbs. N.	845·2	868·7	824·0	846·0
T_4—C.N. 200 lbs. N.	818·7	821·7	804·5	815·0
T_5—Control	671·5	642·0	613·5	642·3
Mean for basal dressings ..	801·4	811·3	769·5	..
Mean for 100 lbs. N.	835·8	861·9	802·8	833·5
Mean for 200 lbs. N.	831·9	845·2	814·2	830·5

Conclusion at 5%
(i) Basal dressings—Non significant.
(ii) Forms of Nitrogen—Non significant.
(iii) Doses of Nitrogen $\overline{100 \quad 200}$ control. C.D. in mds.
833·5 830·5 642·3 32·62

1955–56

		D_0	D_1	D_2
M_1	..	..	592·3	672·3
M_2	..	..	656·8	715·8
M_3	..	..	592·8	652·3
M_4	..	..	557·3	601·5
M_5	..	..	609·5	683·3
M_6	..	..	557·0	636·8
Control	..	454·9	..	..
Mean	..	454·9	594·3	660·3

Manures	M_2 686·3	M_5 646·4	M_1 632·3	M_3 622·8	M_6 586·5	M_4 579·4	C.D. at 5% 62·52 mds.
Doses		D_2 660·4	D_1 594·3	D_0 458·8			67·6 mds.

experiments conducted at Pratap Garh Farm (1939) in U.P. with ammonium sulphate, sodium nitrate and potassium nitrate did not show any distinct superiority of one over the other. Similarly experiments conducted at Padegaon (Bombay) in 1939 showed that ammonium sulphate, potassium nitrate and calcium cyanide were equally good fertilizers. Gahlot (1954) reported that ammonium sulphate, ammonium nitrate and sodium nitrate gave equal cane yield when compared on equivalent nitrogen basis. Thus the findings reported in this paper are in conformity with the conclusions arrived at by the above workers.

SUMMARY

The results of two manurial trials conducted at the Sugarcane Research Station, Jullundur to compare the relative efficiency of ammonium sulphate, chilian nitrate and groundnut cake with regard to their effect on nitrogen uptake, soil composition, juice quality and yield of cane are reported in this paper.

(i) Application of nitrogen in general resulted in an increased uptake of this nutrient irrespective of the form of its application. The availability of this nutrient as shown by the nitrogen content in the leaf tissue was greater in case of chilian nitrate followed by ammonium sulphate and groundnut cake. The absorption of nitrogen under 200 lbs. nitrogen was higher as compared to that of 100 lbs.

(ii) In the case of chilian nitrate application there was comparatively less residual nitrogen in the soil at the time of harvest. Farmyard manure and groundnut cake slightly improved the organic carbon status of the soil.

(iii) Nitrogen in general delayed the maturity of cane. Ammonium sulphate had a greater depressing effect on the juice quality than chilian nitrate.

(iv) The three fertilizers were equally effective as a source of nitrogen as shown by the non-significant differences in cane yiled. There were no significant differences in cane yield due to 100 and 200 lbs. nitrogen.

Acknowledgment

The authors wish to express their thanks to the Indian Central Sugarcane Committee for partly financing the Sugarcane Research Scheme under which these investigations were carried out.

REFERENCES

Borden, R. J. (1945). The effect of nitrogen fertilisation upon the yield and composition of sugarcane. Hawaiian Planter's record, **49**, No. 3 and 4, 259, 299.

Casey, J. M. and Robinson, P. (1953). The manuring of sugarcane. *Empire J. Expt. Agric.*, **21**: No. 82, 99-115.

Gahlot, K. N. S. (1954). Different forms of inorganic nitrogen manures in sugarcane cultivation. *Proc. 2nd Bien. Conf. Sug.cane Res. & Dev. Workers;* Jullundur: 451-56.

Khan, A. R., Misra, K. P. and Alam Masud (1954). Studies on the relative efficiency of different forms and doses of nitrogen with and without weedicides on the yield of sugarcane. *Proc. 2nd Bien. Conf. Sug.cane Res. & Dev. Workers*: 457-62.

Rege, R. D. (1939). Fertilizer experiments on sugarcane in India. 1932-39.

DETERIORATION IN THE QUALITY AND QUANTITY OF *GUR* AND *KHANDSARI* SUGAR AS A RESULT OF STALK BORER INFESTATION

By

B. D. Gupta and J. P. Kulshreshtha

(Indian Institute of Sugarcane Research, Lucknow, U.P.)

THE stalk borer, *Chilotraea auricilia* Ddgn. is one of the most important regional borers of sugarcane crop in India. It infests the grown up canes in Uttar Pradesh and Bihar during the period July-December every year. It inflicts heavy losses in yield and sugar. Gupta and Singh worked out the 'mill loss' at Jarwal Road in Uttar Pradesh in 1950; while Avasthy and Kulshreshtha (1957) have estimated the 'field loss' at Lucknow. As two thirds of the total cane produced in the two States is diverted towards the manufacture of *gur* and *Khandsari* sugar, it is worthwhile to determine the losses in quantity and deterioration in the quality of the produce that the two important cottage industries suffer as a result of borer attack. Such study could be possible only in 1957-58 when sugarcane crop at the Institute Farm had an unprecedented heavy borer attack. The details regarding the assessment of the losses caused by the heavy infestation of stalk borer, *C. auricilia* in the quality and quantity of the *Gur* and *Khandsari* sugar are given in this paper.

Method

Six cane varieties, namely, Co. K. 41, Co.S. 416, Co. 313, Co. 453, Co. 527 and Co. 617 grown under identical manurial, irrigational and cultural conditions were studied for the losses in *gur* and *Khandsari* sugar. The planting of these varieties was done in 0·40 acre plots during the autumn of 1957 and they were harvested in January, 1958. The borer incidence was recorded by examining 500 canes drawn out at random from all the harvested (millable) canes in each of the six varieties; while the intensity of borer damage in the infested canes was determined by longitudinally splitting open 100 infested canes and recording the number of healthy and bored internodes. Three categories of samples viz., healthy, bored and composite were made to determine the juice quality. The composite sample comprised of healthy and bored canes in the same proportion in which they occurred in the field. Five to ten maunds of cane from the composite sample was taken for the manufacture of *gur*; while for *Khandsari* production 100 mds. of the millable cane formed the sample. These were weighed separately and the quantity of juice extracted and *gur* and *Khandsari* produced from each sample were recorded. For estimating the amount of losses in terms of money a recovery of ten per cent in *Gur* and five per cent of *Khandsari* were taken as the standard.

Borer Infestation and Reduction in Yield.—The reduction in per acre yield in the different varieties was worked out by weighing all the millable canes of each variety and comparing the data with average yield (per acre) recorded during the previous three years. The data along with the incidence and intensity of borer infestation are presented in Table I.

Table I

Decrease in yield as a result of borer attack during 1957-58

Variety	Borer incidence %	Internodes bored %	Yield per acre in Mds.		Decrease in yield per acre	Decrease per acre %	Loss per acre in terms of money
			During 1957–58	Average of preceding 3 years			
Co. 313	99·8	35·79	372·2	497·71	125·51 Mds.	25·1	164·42
Co. 453	89·2	23·45	589·8	712·76	122·96 „	17·1	161·08
Co. 527	94·8	23·96	581·79	766·97	185·18 „	24·1	242·58
Co. 617	96·2	27·30	608·62	734·92	126·30 „	17·1	165·45
Co. S. 416	85·2	21·93	446·36	450·00	3·64 „	0·8	4·77
Co. K. 41	98·2	33·22	484·92	761·12	276·20 „	36·2	361·82
		Average ..	..	..	139·96 „	20·0	183·35

A comparison of the produce obtained during 1957-58 (borer year) with the average yield recorded during the preceding three years reveals an average loss of 140 mds. per acre amounting to 20 per cent reduction in yield per acre. The losses were heavy in all the varieties except Co.S. 416 which inspite of 85 per cent borer infestation did not deteriorate to any appreciable extent.

Deterioration in Juice Quality

The effect of borer incidence on the quality of the juice was assessed by analysing the samples for brix, pol. and purity. The data are presented in Table II.

Table II

Effect of borer Incidence on juice quality

Variety	Type of samples	Juice quality on 10–1–58		
		Brix	Sucrose %	Purity coefficient
Co. 527	Healthy Bored Composite	16·11 13·62 13·09	13·27 10·59 9·90	82·37 77·77 76·10
Co. 453	Healthy Bored Composite	18·77 16·96 ..	15·96 13·91 ..	85·02 81·61 ..
Co. 617	Healthy Bored Composite	16·92 14·06 14·06	14·09 10·30 11·61	83·27 73·24 82·63
Co. S. 416	Healthy Bored Composite	20·52 19·2 19·69	18·48 17·32 17·68	90·05 90·20 89·58
Co. K. 41	Healthy Bored Composite	15·71 12·86 12·51	12·46 9·22 8·55	79·31 71·69 68·34

Co. 313 recorded almost 100 per cent infestation, it could not be, therefore, possible to prepare an unattacked sample to properly assess the deterioration in juice quality. However, all the varieties recorded considerable decrease in sucrose and purity co-efficient in juice as a result of high borer attack. This deterioration was remarkably low in Co.S. 416.

Recovery of *Gur* and *Khandsari*

The juice from the composite samples was boiled and converted into *Gur* and *Khandsari*. The reduction in production from the normal is shown in Table III.

Table III

Decrease in Gur *and* Khandsari *in relation to Borer attack*

Variety	Borer incidence	Per cent internodes bored	Recovery of *gur* (%)	Recovery of Ist Sugar (%)	Recovery of IInd Sugar (%	Recovery of IIIrd sugar (%)
Co. 313	99·8	35·79	8·35	3·22	0·88	0·29
Co. 453	89·2	23·45	6·43	2·83	0·77	0·28
Co. 527	94·8	23·06	7·77	2·78	0·76	0·25
Co. 617	96·0	27·30	8·77	2·78	0·76	0·25
Co. S. 416	85·2	21·93	9·17	4·95	1·35	0·45
Co. K. 41	98·2	33·22	4·02	1·74	0·47	0·17
Average	93·8	27·60	7·41	3·05	0·83	0·28
Normal recovery	..	..	10·00	3·67	1·00	0·33

As a result of heavy borer attack there has been considerable reduction in the production of *gur* and the different grades of *Khandsari* when compared with the normal recovery. The variety Co.S. 416 suffered the least in *Gur* and *Khandsari* production inspite of heavy borer infestation.

Loss in Gur Per Acre

On the basis of the actual yield per acre the reduction in production of *gur* from the different varieties is shown in Table IV.

TABLE IV

The decrease in gur *recovery and monetary loss per acre*

Variety	Yield per acre in Mds.	Quantity of *gur* produced per acre Mds.	Quantity of *gur* that would have been produced had the cane been healthy	Loss in quantity of *gur* per acre	Cost of *gur* @ Rs. 13/- per Md.
Co. 313	497·71	41·56	49·77	8·21	106·73
Co. 453	589·80	37·92	58·9	20·98	272·74
Co. 527	766·97	59·59	76·69	17·10	222·03
Co. 617	734·92	64·45	73·49	9·04	117·52
Co. + S. 416	446·36	40·93	44·63	3·70	46·01
Co. K. 41	484·92	19·49	48·49	29·00	377·00
Average	586·78	43·99	58·66	14·67	190·69

As is evident from Table IV the deterioration in the quality of juice has been fully borne out by the quantity of *gur* produced under each variety. A comparison with the calculated recovery of *gur*, had all the canes been healthy, shows a loss of about 15 mds. in the production of *gur* per acre. Co.S. 416, on account of its tolerant nature has recorded the least loss as compared to other varieties. Besides, the quality of *gur* was poor both in texture and colour and fetched a price of Rs. 10/- per maund only when good quality *gur* was fetching Rs. 13/- per maund in the market.

Loss in Khandsari sugar

The decrease in the production of *Khandsari* sugar from the different varieties has been shown in Table V.

TABLE V

Reduction in the recovery of Khandsari *sugar in relation to monetary loss per acre*

Variety	Quantity of sugar produced per acre (Mds.)	Quantity of sugar that would have been produced per acre (Mds.)	Total loss	
			Sugar in Mds. (per acre)	Money Rs. nP.
Co. 313	21·85	24·89	3·04	86·80
Co. 453	22·64	29·49	6·85	195·90
Co. 527	29·07	38·35	9·28	264·94
Co. 617	27·84	36·74	8·90	223·96
Co. S. 416	30·12	30·12	Nil	Nil
Co. K. 41	11·54	24·25	12·71	362·22
Average	23·84	30·64	6·80	188·97

As is evident from Table V Co.S. 416 did not record any decrease in sugar recovery as a result of borer attack. The tolerance of this hybrid to borer damage was thus confirmed beyond doubt. Co.K. 41 recorded maximum loss by showing a reduction of 9·36, 2·57 and 0·78 mds. (per acre) in I, II and III sugars, respectively. However, the average loss for all the six varieties was 4·84, 1·35 and 0·43 maunds per acre, in I, II and III sugar, respectively, costing Rs. 188·97 nP. (Rs. 145·20 for I, Rs. 35·18 nP. for II, and Rs. 8·70 nP. for III sugar).

Conclusions

The broad conclusions derived from this study are as follows :—

1. The loss in yield of sugarcane per acre, at very high borer infestation, amounts to about 140 mds. on an average.

2. The deterioration in juice quality manifests itself by a decrease in the sucrose contents in juice by 5 to 25 per cent and also through reduction in the quantity and quality of Jaggery and *Khandsari* produced.

3. The quality of *gur* greatly deteriorates and the production gets reduced by about 2·6 per cent, on an average.

4. The decrease in the output of *Khandsari* sugars works out to about 1·0 per cent.

5. All the sugarcane varieties showed losses in *gur* and *Khandsari* sugar though Co.S. 416, being tolerant to borer attack recorded the least damage.

6. A cultivator, thus, suffered a field loss of about Rs. 183·35 nP. in the output of sugarcane per acre, besides an additional loss of Rs. 190·69 nP. per acre if he ventured to prepare *gur* or of Rs. 188·97 nP. in the manufacture of *Khandsari* sugar.

It is needless to point out that the above losses are only a conservative estimate since in the absence of Co.S. 416 the averages would have been considerably high.

Summary

Losses in the yield of sugarcane per acre as well as in the production of *gur* (Jaggery) and *Khandsari* sugars as a result of stalk borer, *C. auricilia* attack have been worked out by the authors at the Indian Institute of Sugarcane Research, Lucknow during 1957-58 crop season. The borer infestation being very high (85-100 per cent) in almost all the varieties grown at the farm the losses as worked out are supposed to represent maximum deterioration that the sugarcane hybrids can undergo. The field loss as denoted by the decrease in the yield of sugarcane averaged to 139·96 mds. per acre resulting in a net loss of about Rs. 183·35 nP. per acre when the cost of cane is calculated at Rs. 1·31 per md. Average decrease in the production of *gur* and *Khandsari* sugar worked out to about 25·8 per cent and 20·0-22·7 per cent, respectively. This amounted to a reduction in total production by 14·67 mds. in *gur* and 4·84, 1·35 and 0·43 mds. in I, II and III (*Khandsari*) sugars, respectively. At this rate the losses in terms of money worked out to Rs. 183·35 nP. per acre for sugarcane, Rs. 190·69 nP. for *gur* and Rs. 188·97 nP. per acre in *Khandsari* sugars.

Acknowledgments

The authors are grateful to Sri P. N. Avasthy and the staff of the Entomology Section for help rendered in ths work and to Sri K. S. Saxena, Chemist-in-charge, Gur and Khandsari Research Scheme for arranging to prepare *gur* and *Khandsari* sugar from the entomological samples.

References

Gupta, B. D. and Singh, K. G. (1950). *Jour. Agril. & Ani. Husb., U.P.*, **II**: No. 4, 12-20.
Kulshreshtha, J. P. and Avasthy, P. N. (1957). *Proc. 3rd Bien. Conf. Sug.cane Res. & Dev. Workers*, India, Pusa (Bihar), October.

RUST ON SUGARCANE IN ANDHRA PRADESH

By

P. Prakasam and N. V. Mohan Rao

(*Sugarcane Research Station, Anakapalle, Andhra Pradesh*)

Introduction

Among the varieties tested in cultivators' holdings about a little over a decade ago, variety Co. 475 was found to be a rich cane giving fairly high yield of cane and very good quality jaggery. It was first noted to be highly susceptible to smut and hence was not recommended for general cultivation. However, it stuck on to certain localized pockets near about Anakapalle and two or three villages in the Pithapuram Sugar Factory area. Here, crops of this variety in all stages of growth were found to have been affected by rust when the senior author visited the same recently. In crops which were two months old all the leaves, except the heart leaf, became rusty. In older crops, however, the infection was mild. It may be said that Co. 475 could be identified with the presence of rust on its leaves in view of the invariable association of the disease with this variety. Information collected in the course of examination of incidence of rust on Co. 475 and other varieties at Anakapalle and other areas in Andhra Pradesh is presented in this paper.

Review of Literature

Butler (1918) reported the occurrence of *Puccinia kuehnii* (*Kr.*) Butl. on a number of wild *Saccharum* spp. in India but not on any cultivated sugarcane. He, however, doubted the immunity of Indian Sugarcane to this fungus.

Patel *et al.* (1950) recorded a species of *Puccinia* on the Sugarcane variety Co. 475 in Bombay. The general characters and description of spore forms of this new species were similar to those reported by Butler for *P. kuehnii.* But the size of teliospores obtained from Co. 475 was much larger than that reported by Butler on *S. spontaneum.* Whereas the telial stage of *P. kuehnii* occurred only rarely it was very common in this species collected by these authors. This fungus was, therefore, considered a new species and named as *Puccinia sacchari.*

Chona and Munjal (1950) reported the occurrence of *P. kuehnii* on Co. 475 from Bombay. Chenulu (1954) observed a severe attack of rust (*P. kuehnii*) on Co. 876 at Nellikuppam (Madras) in August 1952. Syed Vaheeduddin *et al.* (1955) reported the incidence of rust on eight varieties, viz., Co. 421, Co. 467, Co. 475, Co. 603, Co. 658, Co. 678, Co. 732, and POJ. 2878 in Hyderabad. The fungus was identified as *P. kuehnii.*

Srinivasan and Chenulu (1956) observed that natural incidence of rust on *Saccharum spontaneum* was heavy. In general, only the leaf blades showed the rust but in some variants the leaf sheaths and the stems also bore the pustules. Only the uredia were encountered and the characters of the uredial stage were found to be in agreement with those of *P. kuehnii.* The rust was noted to affect a large number (127) of *S. spontaneum* variants in the cooler months. The authors have also noted that the rust affected mostly the narrow and medium leaved variants while the broad leaved ones were, in general, not affected.

Tandon *et al.* (1957) reported the occurrence of *P. kuehnii* in Uttar Pradesh on Co. 313, Co.S. 510 and *S. spontaneum.* They observed that heavy infection occurred in autumn planted crop while spring planted crop was comparatively free from the disease. Only the uredio spores were met with.

Sharma *et al.* (1957) noted the occurrence of rust in Bihar on some sugarcane varieties viz., Co.S. 416 and Co.S. 510. Size of uredio spores of the rust occurring on Co.S. 510 and those of *P. kuehnii* occurring on *Erianthus arundinaceus* were compared and significant differences in lengths and breadths of teliospores of the two rusts were noted. While teliospores were commonly found in the rust on Co.S. 510 they were not found in the rust on *E. arundinaceus.* The authors deferred identification of the rust on Co.S. 510 till further information was obtained by cross-inoculations.

Occurrence of Sugarcane Rust in Andhra Pradesh

The incidence of rust on Sugarcane was noted in December 1954 for the first time at the Sugarcane Research Station, Anakapalle. In a field where 125 varieties were being grown as a short crop, only two

varieties viz., Co. 992 and Co. 993 were found affected by rust, while the rest of the varieties remained free from the disease. Prompt action was taken to control the disease by uprooting and burning the affected plants. The disease occurred again in December 1955 in three varieties viz., Co. 986, Co. 987 and Co. 1019 out of 103 varieties being grown as short crop in one field. As in the previous year, the affected crop was removed and burnt. In the subsequent two years, 1956-57 and 1957-58, however, no incidence of rust was noted in the varieties grown on the research station. The disease was, again observed in January 1958 in a cultivator's field at Anakapalle. The variety affected was Co. 475 and the crop was about ten months old at the time of observation. This variety was grown in about an acre and the whole crop in the field was affected by the disease. Co. 419 growing adjacent to Co. 475 was found quite free from the disease. But Co. 475 presented a dry and sickly appearance. Hence it appears as though infection might have started earlier than January as was noted on the Research Station on previous occasions.

Disease Characters

The infection occurred on leaf blades only. Leaf sheaths were almost free from the disease. Both *uredio* and *teliospores* were produced. In the fresh pustules only the uredio spores were produced and *teliospores* were seen rarely. But in the old pustules, both *uredio* and *teliospores* were seen, the latter being in larger numbers. The symptoms of the disease and the characters of the sori are in general agreement with those described by other workers in respect of *P. kuehnii*.

The mean values of *uredio* and *teliospores* are given below :—

Spores	Range (in μ)	Mean (in μ)
Uredio spores ..	24·0–43·4 × 18·2–30·5	34·5 × 24·3
Telio spores ..	30·0–58·8 × 14·9–28·0	43·1 × 19·0

The spore sizes were compared with those recorded for sugarcane rust fungus by other workers as shown in the following table :—

Some measurements of Sugarcane Rust Fungus

S. No.	Species of the fungus	Host and locality	Spore measurements in microns — Uredio spores — Range	Uredio spores — Mean	Teliospores — Range	Teliospores — Mean
1.	*Puccinia kuehnii* (Kr) Butl. (Butler 1918)	Wild Saccharums– (India)	29·0–57·5 × 18·0–34·5	48·0 × 27·0	25–40 × 10–18	..
2.	*P. sacchari Patel et al.* (Patel *et al.* 1950)	Co. 475 (Bombay)	32·2–62·6 × 21·7–41·7	43·3 × 30·8	32·0–85·5 × 16·2–37·1	51·0 × 26·4
3.	*P. Kuehnii* (Kr) Butl. (Chona and Munjal 1950)	Co. 475 (Bombay)	21·0–40·0 × 20·0–25·0 length mostly 27–35	..	30·0·57·0 × 17·0–22·0 Length mostly 38–48	..
4.	*P. Kuehnii* (Kr) Butl. (Chenulu 1954)	Co. 876 Nellikup-pam (Madras)	23·8–54·4 × 13·6–37·4	27·6 × 19·7	30·6–57·8 × 17·0–20·4	41·2 × 18·5
5.	*P. Kuehnii* (Kr) Butl. (Syed Vaheeduddin *et al.* 1955)	Co. 421, Co. 467, Co. 475, Co. 603, Co. 658, Co. 678, Co. 732, POJ. 2878 (Hyderabad)	Similar to those reported by Chona *et al.* 1950.			
6.	*P. Kuehnii* (Kr) Butl. (Srinivasan and Chenulu 1956)	S. Spontaneum Variants (Coim-batore)	30·6–57·8 × 20·4–37·4	..	Teliospores not met with.	
7.	*P. Kuehnii* (Kr) Butl. (Tandon *et al.* 1957)	Co. 313, Co. S. 510 and *S. Spontaneum*	44·6–26·4 × 26·4–19·8 The sizes of spores on different host varieties are almost similar.	35·6 × 23.5	Not met with.	
8.	Undetermined (Sharma *et al.* 1957)	Co. S. 416 and Co. S. 510 (Bihar)	*16·5–42·0 × 13·5–28·5	29·7 × 21·9	Not given.	
9.	Rust reported by the authors of this paper	Co. 475 (Anakapalle)	24·0–43·4 × 18·2–30·5	34·5 × 24·3	30·8–58·8 × 14·9–28·0	43·1 × 19·0

* Spores from Co. S. 510 only.

Details furnished in the above table disclosed some variation in the size of spores of *P. kuehnii* recorded by different workers. However, the size of spores of the rust fungus recorded at Anakapalle is within the ranges reported for *P. kuehnii.* It is, therefore, considered likely that the rust occurring on sugarcane at Anakapalle is *P. kuehnii* (Kr.) Butl.

Summary

Occurrence of rust on sugarcane in different states of India has been briefly reviewed. The incidence of the disease in Andhra Pradesh on Co. 475 and a few other varieties has been described. The sizes of the spores of the rust fungus occurring on Co. 475 in Anakapalle have been measured and they are compared with those of the sugarcane rust fungi reported from other States in India. There is some variation in the measurement of spores of *P. kuehnii* (Kr.) Butl. reported by other workers. However, the size of spores of the rust fungus recorded at Anakapalle has been found within the ranges reported for *P. kuehnii* (Kr.) Butl.

Acknowledgment

The authors' thanks are due to Indian Central Sugarcane Committee, New Delhi for partly financing the Research Scheme on this station.

References

Butler, E. J. (1918). Fungi and disease in plants. Thacker Spink & Co., Calcutta.
Chenulu, V. V. (1954). Rust on Co. 876, a cultivated variety of sugarcane. Second Biennial Conference of Sugarcane Research Workers in India, 1954.
Chona, B. L. and Munjal, R. L. (1950). *Puccinia kuehnii* (Krueg.) Butler on Sugarcane in India. *Current Science*, **XIX:** 151—52.
Patel, M. K. *et al.* (1950). A new record of *Puccinia* on sugarcane in Bombay. *Current Science*, **XIX:** 121.
Sharma, S. L. *et al.* (1957). A rust on sugarcane in Bihar. *Ind. J. Sug.cane Res. & Dev.*, **II**(1): 49.
Srinivasan, K. V. and Chenulu, V. V. (1956). A preliminary study of the reaction of *Saccharum spontaneum* variants to Red rot, smut, rust and mosaic. International Society of Sugarcane Technologist, 9th Congress, India in January 1956.
Syed, Vaheeduddin *et al.* (1955). Sugarcane Rust in Hyderabad State, *Science and culture*, **21:** 328-29,.
Tandon, R. K. *et al.* (1957). Occurrence of sugarcane Rust in Uttar Pradesh. *Indian Sugar.*, February 1957.

PESTS AND DISEASES OF SUGARCANE IN BOMBAY STATE

By

R. M. Patel

(Sugarcane Development Scheme, Ahmednagar, Bombay State)

Introduction

THE problem of the pests and diseases of sugarcane in Bombay State is different from that in North India in many respects. Firstly, the cane area in Bombay State is mainly concentrated in the Deccan tract which is situated in the tropical belt suited for a very high cane yield. Secondly, a heavy cane crop is raised under deep cultivation of soil, heavy manures and perennial irrigation. Thirdly, the system of Adsali planting is followed, under which the cane is planted in July and taken as a 18 months crop, as a result of which a continuous heavy crop is available for pests and diseases throughout the year. And fourthly, the winter being not severe, many of the pests which normally hibernate in North India during the cold season do not do so in the Bombay Deccan.

A note was published by the author in 1954 in the " Farmer " giving an account of the work done for the protection of sugarcane crop from pests and diseases in Bombay State. In that note, although the information regarding the area affected by various pests and diseases and the area treated against them during the previous five years was given, no attempt was made to give an account of the fluctuations in the incidence of pests and diseases that occurred as a result of the control measures carried out against them. Attempts have therefore been made here to give an account of the position of pests and diseases from their incidence point of view, during the last eight years.

History

The work of controlling the pests and diseases of sugarcane in Bombay State was started with the commencement of the Sugarcane Development Scheme from 1st August, 1948. Wagle (1953) and Raja Rao (1953) have published notes discussing the value of certain control measures against Top shoot borer. Further Wagle has also discussed the control of Pyrilla, mentioning mainly the role of a parasitic fungus (*Metarrhyzium anisoplae*) in controlling that pest. The author in 1954 explained the role of this parasitic fungus in controlling the Pyrilla pest in the field.

Major Pests of Sugarcane

The survey of incidence of pests and diseases carried out in Bombay State annually since 1951-52 indicate the following pests to be the major ones :—

Top shoot borer (*Scirpophaga nivella*)
Stem borer (*Chilotraea infuscatellus*)
Pyrilla (*Pyrilla perpusilla*)
Grasshopper (*Hieroglyphus banian* var. *elongata*)
Sugarcane mealy bug (*Trionymus sacchari*)

The following are the minor pests of sugarcane :—

Sugarcane mealy wings (*Aleurolobus barodensis*)
Termites
White grubs
Mites
Field rats

The survey of incidence of pests and diseases indicate the following diseases to be the major ones :—

Rust (*Puccinia kuehnii*)
Whip smut (*Ustilago sacchari*)
Twisted top
Grassy growth
Twisted top and Grassy growth are new diseases.

The following may be taken as the minor diseases :—

Red Rot (*Colletotrichum falcatum*)
Wilt disease (*Cephalosporium sacchari*)
Brown leaf spot disease (*Cercospora longipes*)
Red sheath disease (*Mycelia sterilia*)
Mosaic disease

Technique Adopted for Survey

The estimation of incidence of pests and diseases on sugarcane crop was carried out every year in all the beats of the Agricultural Assistants in the Deccan Tract, each beat including 1,000 to 2,000 acres of sugarcane. The incidence of pests and diseases was estimated by counting the number of affected plants or shoots out of the total plant or shoot population in six strips, each ten feet in length, selected at random in each patch or group of fields of cultivators and in each *wadi* or circle in fields of sugar factories. The estimation by counting the affected plants or shoots was possible in case of such pests and diseases as top shoot borer, stem borer, smut and red rot. In the case of pests, like grasshopper, pyrilla and mealy bug and of diseases like rust, the intensity of attack was recorded by obtaining an idea of insect population or damage done to plants by eye judgement based on experience gained.

Attack of Pests During the Last Eight Years

Top shoot borer.—Infestation by this pest was not heard of before 1940 in the Bombay Deccan. According to Raja Rao (1953) it was first observed at Boregaon Sugar Factory in 1940. Gradually the pest multiplied and by 1950 its infestation reached 20 per cent. On the estate of Belwandi Sugar Factory the infestation reached as much as 40 per cent in one block. The mechanical measures consisting of the collection of egg masses and the destruction of affected plants in the early stages of the cane growth were applied on a large scale on the estate of Belwandi Sugar Factory in 1950, as a result of which the infestation of top shoot borer which was 20·9 per cent in *Adsali* cane during July-August 1949 came down to 4·4 per cent during July-August in 1951. This work at Belwandi proved the efficacy of the mechanical measures in controlling the top shoot borer. Consequently the measures were recommended to other factories and cultivators in the operational area of Sugarcane Development Scheme. Now the application of the mechanical control measures against the top shoot borer has become a routine with the cane growers.

The position of the infestation by top shoot borer, as evinced from the appearance of the tunnel (greenish streak) along the midrib on the upper surface of the first and third functional leaves, presence of shot holes in the second functional leaf and absence of the tiny innermost leaf in the spindle, in the fields of both cultivators and factories during the last eight years is shown in Table I.

Table I

Infestation by Top Shoot Borer

Year	Area over which observations were made (in acres)		Range of percentage infestation in fields of	
	Cultivators	Factories	Cultivators	Factories
1950–51	42,161	..	4–21	..
1951–52	44,532	36,998	3–10	1–12
1952–53	40,168	35,025	3·4–10·2	2–12·4
1953–54	43,500	37,155	1·7– 7	0·8– 4·2
1954–55	47,275	39,537	1·4– 5·3	1·0– 3·7
1955–56	50,948	42,365	1– 5·2	0·1– 5·5
1956–57	52,765	37,699	1·3– 5·8	0·8– 7·8
1957–58	53,482	33,259	1– 3·4	0·7– 4·2

It is obvious from the data given in Table I that the mechanical control measures were successful in maintaining the infestation by top shoot borer at a low level.

Stem borer.—The infestation by stem borer is noticeable outwardly in the very early stages of the crop, from the presence of the dead hearts. However, if the canes in the advanced gorwth of the crop are split open, it will be noticed that canes get infested by the stem borer throughout the year. The infestation is not noticeable in the advanced stages of the crop growth because the larvae of the stem borer are not capable of causing dead hearts in canes at those stages.

The control measures that were tried against this pest were (i) destruction of dead hearts and larvae inside, (ii) two light earthings and (iii) release of Trichogramma parasite @ 1,00,000 per acre in three instalments at fortnightly intervals. Of the above methods the third one, namely, the release of Trichogramma parasites had become popular with the cane growers as could be seen from the demand on account of the cheapness and simplicity of the method, but the same had to be abandoned in the year 1954-55 as per the decision taken by the *Ad-hoc* Entomology Sub-Committee appointed by the Indian Central Sugarcane Committee, as it was found that the results at Walchandnagar were not significantly effective. From 1954-55, therefore, the destruction of dead hearts along with the larvae became the main control measure.

The position of the infestation by stem borer as evinced from the presence of dead hearts during the last eight years is shown in Table II.

TABLE II

Infestation by Stem Borer

Year	Range of percentage infestation in fields of	
	Cultivators	Factories
1950–51	3–16	..
1951–52	3–10	1–8
1952–53	4–10	0·9–11
1953–54	3–6·51	1·6–5·9
1954–55	1·8–7	1·1–3·6
1955–56	0·4–7	0·5–6
1956–57	2–9·3	0·5–3·4
1957–58	1·4–4·5	0·5–4·8

Pyrilla.—Pyrilla multiplied considerably in 1950-51 even though it has been making its appearance in a mild form since 1946. The attack of this pest was severe in 1951-52. During this year cane growers were advised to carry out dusting with five per cent or ten per cent B.H.C. which was found to be effective in trials. The dusting, however, could not be carried out in the fields of *Adsali* cane which had lodged. It was experienced by cane growers during that year that the egg parasite (*Tetrastichus pyrillae*) which could be noticed in fields throughout the duration of pyrilla attack and a fungus parasite identified as *Metarrhyzium anisoplae* which appeared only late in monsoon, played a very important role in putting down the pest, which, however, could occur at the end of monsoon only. There was serious damage from pyrilla in 1952-53 and 1953-54. The parasitization by *Tetrastichus pyrillae* (which is usually noticed to be active throughout the period of pyrilla attack) was found to be varying during the monsoon of 1952 at the following rate :—

33·3 per cent in June.
78·3 per cent in August.
19·8 per cent in December.

During the monsoon of 1953, the attack of the pest was again very severe in Ahmednagar district, and though the egg parasite (*Tetrastichus pyrillae*) was active throughout the monsoon when the attack of pyrilla was going on, it alone was not able to put down the pest. However, at the end of the monsoon when the fungus parasite appeared in nature, the attack of the pest subsided completely and the presence of the fungus was noticeable on dead adults of pyrilla. This phenomenon created impression among cane growers that the fungus would now control the pest and that they would not be required to do anything else. It was,

however, not realised by them that the fungus appeared very late in nature i.e. when the crop was ready for harvest and after the pest had done sufficient damage. The author (1954 and 1956) attempted to explain the difficulties observed in the working of the fungus appearing in nature. The fungus appears very late in nature and it requires special environmental conditions for multiplication, which cannot be created in fields in other months when the pest usually appears and the multiplication of the fungus is badly needed. Attempts for the artificial multiplication of the fungus in fields have not been successful so far.

The Bombay Pests and Diseases Act, 1947 was applied to the sugarcane area of Ahmednagar district during 1953-54 and subsequent years, for the control of pyrilla by insecticidal measures. The Act is still in force. During the years of 1954-55, 1955-56 and 1956-57 the attack of pyrilla appeared in the lesser area and in mild form only. Again during 1957-58 the attack of the pest appeared in the larger area and in severe form.

During the year 1957-58 the method of aerial spraying for applying insecticides was adopted in some areas for the control of pyrilla. This method was tried in an area of 1,370 acres on the estates of Godawari Sugar Mills Ltd., and in an area of 1,000 acres on the estates of Ravalgaon Sugar Farm Ltd. It was again tried during May 1958 in an area of 3,200 acres on the estates of Belapur Co. Ltd. and in an area of 400 acres on fields of cultivators in Shrirampur area. At all the above places where the aerial spraying was carried out, the results were extremely successful as the pest was completely controlled for that period.

The position of pyrilla during the last eight years is shown in Table III.

TABLE III

Infestation by Pyrilla

Year	Cultivators' area		Factories' area	
	Area affected (acres)	Type of attack	Area affected (acres)	Type of attack
1950–51	1,356	Medium	..	..
1951–52	6,106	Severe	9,492	Mild to severe
1952–53	6,716	,,	4,546	Severe
1953–54	5,370	Very severe	9,441	Very severe
1954–55	3,209	Mild	1,806	Negligible
1955–56	2,263	,,	2,119	Mild
1956–57	1,477	,,	2,825	,,
1957–58	5,469	Mild to severe	8,866	Mild to severe

Grass Hopper.—The Shrirampur taluka of Ahmednagar district was the only place where attacks of the grass hopper occurred every year before 1950. As a result of the effective dusting with five per cent B.H.C. the area of infestation by grass hopper fell from 3,721 acres in 1949 to 758 acres in 1950. In 1951-52 the pest appeared for the first time on Girna canal tract in Nasik district, but by timely measures it was controlled satisfactorily. The grass hopper attack was only slight and in the limited area in the years 1952-53 and 1953-54. Again in 1954-55 the infestation area increased, but the attack was mild only. The position of the attack of the pest during the last eight years is shown in Table IV.

Mealy Bug.—The attack by mealy bug is usually severe in Karnatak region only, which is now a part of Mysore State. It is, however, noticeable in mild form in other areas also, in Bombay State. Cane growers follow the methods of the stripping of dry leaves at the time of harvest and using insect-free seed. Insecticidal measures have not been popular as yet.

ATTACK OF MINOR PESTS

Sugarcane mealy wing.—The mealy wing, which is a serious pest in North India, is entirely absent in Bombay Deccan. It is, however, noticed in South Gujarat in Bombay State. This being a non-operational area under the Sugarcane Development Scheme no concrete information regarding this pest has been collected.

TABLE IV

Infestation by Grass Hopper

Year	Cultivators' area		Factories' area	
	Area affected in acres	Type of attack	Area affected in acres	Type of attack
1950–51	758	Severe	..	..
1951–52	416	Mild	55	Mild
1952–53	208	”	72	”
1953–54	102	”	Nil	”
1954–55	747	”	”	Mild
1955–56	263	Mild to severe	95	”
1956–57	371	Mild	Nil	..
1957–58	301	”	”	..

Termites.—Termites are a minor pest in the Deccan tract and are noticeable in the Belgaum area only, which is now a part of Mysore State. On the estate of Ugar Sugar Works Ltd., where there was an outbreak of termites in 1954-55, the application of five per cent B.H.C. at the rate of 20 lbs. per acre in furrows with setts at the time of planting was found to be beneficial.

White grubs.—These are underground insects and are quite common not only in sugarcane fields but also in the fields of other crops in the infested area. The mixing of five per cent B.H.C. powder in soil at the rate of 20 lbs. per acre was found to be effective in keeping down the grubs.

Mites.—These are sometimes found to be present inside leaf sheaths of cane. No attention, however, was paid to them.

Field rats.—Rats occasionally cause damage to cane crop. Losses occur in the form of injured canes, dead canes and by way of deterioration of juice. It was found that the poison baiting using zinc phosphide as poison reduced the damage by rats. Specimens of rats collected from the fields of Godawari Sugar Mills Ltd. were sent to the Director of Zoological Survey of India, Calcutta, who identified them as *Rattus Rattus refescens* Gray. during the year 1956-57.

ATTACK OF DISEASES DURING THE LAST EIGHT YEARS

Rust.—This disease was found to be severe on Co. 475 grown as *Adsali* cane. Fortunately Co. 419 cane which occupies the most of the cane area in Bombay Deccan was not affected by this disease. As the attack of rust was severe on Co. 475 in 1950-51, the distribution of that variety was completely stopped by Government. Both cultivators and factories appreciated the necessity of discarding Co. 475 with the result that the area under Co. 475 was considerably reduced year after year. In 1954-55 the area under Co. 475 in the fields of cutlivators and those of factories was only 2·7 per cent and 0·09 per cent of the total cane area, and since then the area under that variety has not gone up.

Whip smut.—Whip smut was noticed on both Co. 419 and Co. 475, the only varieties that were any largely grown in Bombay Deccan until recently. The control measures consisting of systematic roguing with the cutting of whip to avoid dispersal of spores and careful selection of cane material are faithfully followed by cane growers. The disease is under check.

Twisted top.—This disease was first reported from the estates of the Belapur Co. Ltd. It was then found at Phaltan, Baramati and Ravalgaon. The symptoms are: (i) Cane stalks remain thin and short internoded and leaves along the cane stick get twisted giving a braid like appearance, (ii) all canes in the affected fields are found to be thin and short internoded. Observations show that this disease was noticed in those fields wherein the cane seed used had not been changed for several years. The disease has been suspected to be of virus origin, but no conclusive evidence on this point is available. Since the seed in the affected area was changed this disease is not found to be in any severe form since 1956-57.

Grassy growth.—This was first reported from the estate of Walchandnagar Sugar Factory, but is now noticeable on the estates of Maharashtra Sugar Factory and also at other places like Baramati, Loni,

Kopergaon and Malinagar. Regarding symptoms, ratoon sprouts develop in grassy growth instead of canes. Yellow-striped leaves are not uncommon among them. The disease is suspected to be of virus origin and is found mainly in ratoons. In severely affected fields, as many as 60 to 80 per cent of stools show grassy growth. It was observed that ratoons from the seed which had not been changed for several years were affected by this disease.

The only control measures that could be applied were (i) to change seed and (ii) to uproot and destroy affected stools as soon as they were seen. The position of the attack of this disease is shown in Table V.

TABLE V

Attack of Grassy Growth

Year	Cultivators' area		Factories' area	
	Area affected in acres	Type of attack	Area affected in acres	Type of attack
1954–55	..	..	..	..
1955–56	114	Medium	1,630	Mild to medium
1956–57	863	Mild to medium	202	,,
1957–58	1,217	,,	457	Severe

ATTACK OF MINOR DISEASES OF SUGARCANE

Red-Rot:—Red-rot was the most serious disease of sugarcane in Bombay Deccan some years ago. With the planting of Co. 419 and Co. 475 as the only varieties in Bombay Deccan, the disease is entirely absent for the past several years.

Wilt disease:—The symptoms of this disease are sometimes found in the canes attacked by shoot borers, but are not commonly encountered.

Brown leaf spot disease:—Co. 419 variety which is resistant to rust is attacked by this disease in Kolhapur area. The spots are confined to the leaf blade and not to the leaf sheath. The vigour of the crop does not seem to be affected by the appearance of the symptoms of this disease.

Red sheath disease:—The attack of this disease is noticeable in Lakhamapur area of Nasik district. The affected sheaths show a distinct bright red discolouration from outside and a mucilaginous or gummy substance from inside.

Mosaic disease:—Mild symptoms of this disease are noticeable on Co. 419 variety on the estates of Changdeo Sugar Factory and Maharashtra Sugar Factory in Ahmednagar district. The symptoms appearing are so mild that the cane yield or recovery of sugar does not seem to have been any substantially affected thereby, so far.

SUMMARY

The top shoot borer which was practically absent before 1940 in Bombay State was multiplying fast but could be kept under check by the rigid application of the mechanical control measures in the fields of both cultivators and factories. Its infestation which had risen upto 21 per cent and even 40 per cent at some places before 1950 came to be as low as below five per cent in 1954-55. Its low level since then has been maintained.

The work of controlling stem borer by the use of Trichogramma parasite was discontinued in 1954-55 at the instance of the Indian Central Sugarcane Committee as the results at Walchandnagar were not found to be significantly effective. The mechanical control measures in the early growth of cane have become successful in keeping the stem borer at a low level.

The attack of pyrilla remained serious for three years from 1951-52 to 1953-54. The egg parasite, *Testrastichus pyrillae* and the fungus parasite, *Metarrhizium anisoplae* helped in putting down the pest every year, but they could do so at the end of monsoon season i.e. after the pest had done its damage since the latter i.e. fungus parasite appeared in nature very late. Unfortunately the fungus required special conditions to multiply, which could not be created in fields in other months when the multiplication of the fungus was required for the control of the pest. Its artificial multiplication in fields could not be successful so far.

The Bombay Pests and Diseases Act, 1947 was applied to Ahmednagar district against Pyrilla in 1953-54 and is still under force. The pyrilla pest which was very serious upto 1953-54 appeared in mild form only in three years that followed. The infestation however became again serious in 1957-58. Aerial spraying was carried out for the control of pyrilla in an area of about 5,970 acres and the results were found very satisfactory.

Grass hopper attack was confined to Shrirampur taluka only in Ahmednagar district and is under check as a result of the application of five per cent B.H.C.

Among diseases, Rust and Whip Smut were the most common. Rust was found to be specific to Co. 475 variety which is being almost completely discarded. Smut which was serious a few years ago has been kept under check by the adoption of suitable control measures in time. Two new diseases, namely, Twisted Top and Grassy Growth have appeared and both of them are suspected to be of virus origin. Grassy Growth appears to be a more serious disease than the other and is confined to ratoons only.

Acknowledgment

The author is grateful to Dr. H. R. Arakeri, the Ex-Sugarcane Specialist, Bombay State, and Shri G. T. Babriwala the present Sugarcane Specialist, Bombay State for giving encouragement and suggestions in writing up this paper.

REFERENCES

Patel, R. M. (1954). *Proc. Deccan Sug. Tech. Assoc.* (India): 88-92.
———— (1955). *Farmer*, **6** (1): 27-29.
———— (1956). *Proc. Int. Soc. Sug. Tech.* 9th Congress, India.
Raja Rao, S. A. (1953). *Proc. Deccan Sug. Tech. assoc.* (India): 72-77.
Wagle, P. V. (1953). *Farmer*, **4** (3): 30-33.

MONSOON PLANTING TO INCREASE ACRE-YIELD AND QUALITY IN NORTH INDIA

By

V. S. YADAVA

(Samastipur Central Sugar Co. Ltd., Samastipur, Bihar)

PREFACE

THE North Indian acre-yield in sugarcane has continued to pull down the Indian average with the result that in production per unit of land, India still records very nearly the lowest figures both in quantity and quality. This is despite the fact that peninsular India has made a remarkable progress in raising acre-yield and this particularly so in the Bombay State which possesses a plantation industry and where capital plays its full and honourable role. The reason is not far to seek and has to be found in the proverbially small holdings, not infrequently scattered and consequent utter poverty of the grower in the north. Besides there is also the lack of one of the major factors of production namely irrigation and the cropping at present is a 'gamble in the monsoon'. Most outstanding achievement of the Bombay Sugar Industry has been its switch over from a 12-month crop to an *adsali* (eighteen months) crop and the resultant rise in the tonnage and recovery. Work attempted in the north, as a general rule and under conditions of inadequate irrigation and fertilization, has resulted in a failure of monsoon planting, although autumn planting is being increasingly adopted, some of the factories covering more than half their acreage under this system in their supply zones. In view of the fact that millable crop is derived from the tiller growths that are laid before the onset of monsoon, any method that can improve its quantum cannot fail to materially add to the area-yield and quality of the crop. Shri Yadava has worked hard to bring about modifications in a system that is well known in the South with a view to make *adsali* planting a real success in the North. Adequate irrigation facilities are still an essential pre-requisite but where these can be obtained, the system of monsoon planting can greatly enhance production per unit of land. The system, therefore, requires large scale experimentation and demonstration to enable cultivating community in the north benefiting from it and through increased production removing the stigma of low acre-yield in the north.—K. L. Khanna.

The average sugarcane yield in India varies greatly from one part of the country to the other, ranging between 40 tons in the peninsular south to about 15 tons in northern India, and even lower in Eastern Uttar Pradesh. This is due to different climatic and soil conditions to a certain extent but other factors like time of planting, methods of cultivation, irrigation and manuring also play an important part. The best season for cane sowing in Bombay extends from middle of June to middle of September and cane is left to grow in the field for about 18 months. This crop is called 'Adsali' and it normally yields about 60 tons per acre.

The main sugarcane sowing period in Uttar Pradesh and Bihar is during February and March. January sowing has shown better results and still better results have been obtained from October planted cane. It will not be wrong to say: "Longer the cane stands in the field, the better is the yield", which is the case with sugarcane in South India. There are no difficulties with Adsali sowing in South India due to light showers during monsoons. In Uttar Pradesh and Bihar it appears difficult to grow cane during this season on account of heavy rainfall. Experiments conducted at various places have not given satisfactory results. The setts planted direct into the trenches suffer from stagnation and excessive moisture, resulting in poor germination. To overcome this draw back and to make monsoon planting successful, a number of experiments have been conducted at the Chehri Farm of Ganesh Sugar Mills Ltd., Anandnagar, District Gorakhpur. Encouraging results have been obtained by altering the methods of sowing and other operations according to needs. Direct planting of setts into the trenches according to prevalent method did not give satisfactory germination due to rotting of buds in excessive moisture caused by heavy rainfall. To overcome this difficulty, separate seed nursery on raised beds was grown and then seedlings were transplanted into the trenches of usual size. This not only solved the problem of stagnation but also afforded better germination, growth and yield. The following are the benefits of rainy season planted cane:—

Better germination:—The cane being unripe during this period, gives better germination due to high content of glucose and the buds at this stage have better sprouting ability. As the cane ripens later on and specially in flowering varieties, the eyes begin to bulge out from the top portion which detracts from their value as planting material. The climatic conditions during this period also help in quicker germination.

Vigorous growth:—The best period of growth of sugarcane in this tract is July to September. It is during this period that sugarcane builds up most of the height. Due to the favourable climatic conditions, the cane starts growing immediately after germination. Sugarcane planted during the second week of July attains a height of over 5 feet by the end of October, whereas, it takes about seven months to grow to this height when planted in October. It has further been observed that the advantage gained in respect of height by monsoon planted cane over February plantings persists right upto the end. This is because the former gets two boom periods of growth instead of one.

Tillering:—The tillering in transplanted cane is more vigorous as in case of transplanted paddy. As soon as the roots establish themselves in trenches after transplanting, tillers emerge and grow along with the mother shoot. The emergence of tillers continues till April and May which is not, however, of much advantage. It will be better if tillers coming very late are cut out to get uniform ripening of cane.

Utility of manures:—The bulky organic and inorganic manures applied before planting in rainy season decompose in the soil earlier as there is sufficient moisture available. The cane planted in July and August gets full advantage of the applied manures. Later on when moisture availability is reduced, there are less chances of spring and autumn planted cane getting the benefit of manures till it is fully decomposed either through heavy irrigation or with the advent of next monsoon.

Ability to withstand heat:—The plants are in better position to withstand heat of the summer season. The roots are fully established and lie deep in the soil. They are able to draw comparatively more moisture from the soil. Similarly the leaves are also sufficiently developed and function better during the hot season.

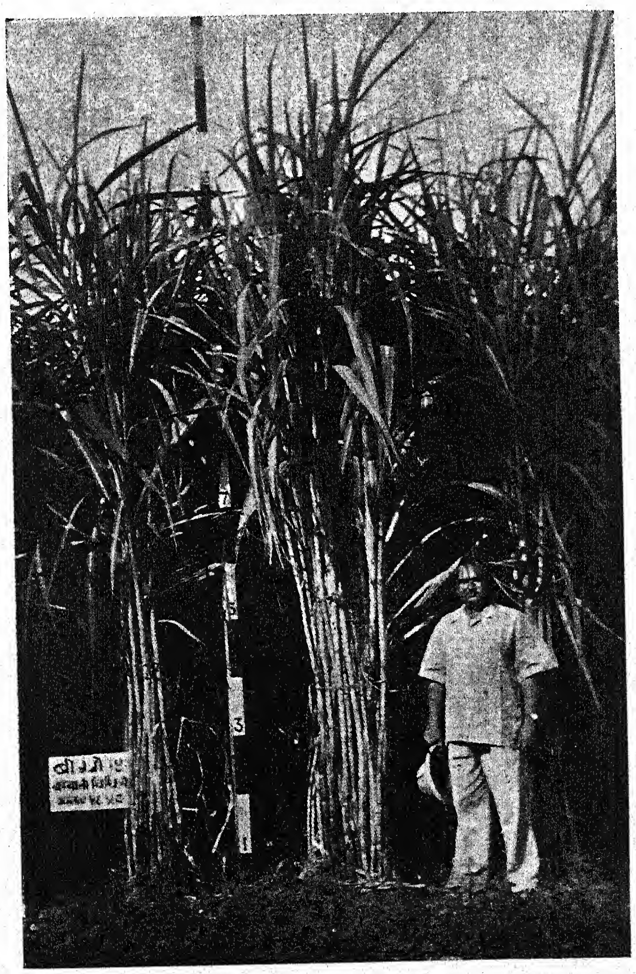


FIG. 1. Monsoon transplanted crop of B.O. 14 as on 31st July, 1959.

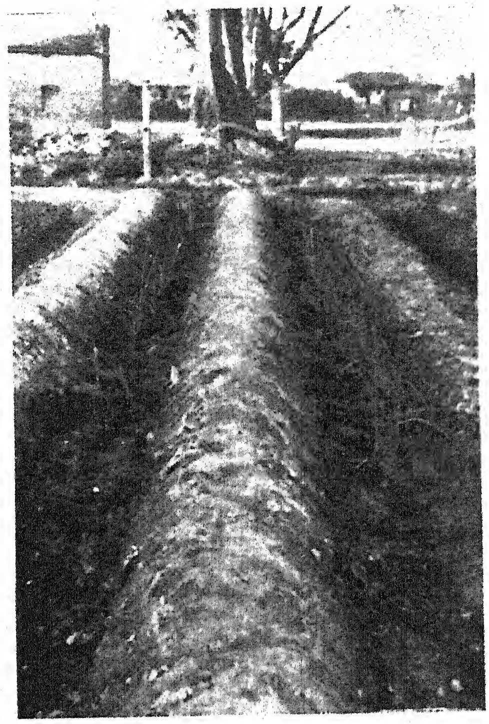


Fig. 2. Newly planted germinated shoots in well prepared trenches.

Early Maturity and better sugar:—Monsoon planted cane in virtue of its remaining in the field for about eighteen months ripens earlier than the autumn or the spring planted crop. The tillers which emerge earlier, are uniformly mature at the time of harvest whereas in the late planted crop, all the tillers do not reach maturity at the same time.

Economy in seedcane:—Only one third quantity of cane seed is required for monsoon transplanting as would be evident from the method described below. Thus only about 20 maunds of cane seed is required as against the normal requirement of 60 maunds per acre and extra expense of raising a seed nursery is fully compensated by the reduced quantity of seed required. The most important factor for Monsoon planting is to plant setts and raise shoots for planting irrespective of the rains which generally occur during this period in these tracts. The following three methods were found successful in obviating the adverse effect of heavy showers in the early stages. Of these the last one was found the most suitable in all respects. The first method is called 'Rayagen' which is in practice at Kolhapur i.e. fixing of three-budded setts in raised seed beds at 45° angle with one bud embedded in the soil and two buds left to sprout above ground. In this method, with the establishment of roots, the top and the middle buds germinate in order, the bottom one being the last to develop. The setts are taken out after three weeks and each shoot with a small portion of sett is separated and planted in well prepared trenches. The bottom shoot is usually discarded because of its poor development.

In the second method after preparing the plot and the trenches, three-budded cane setts are placed on the top of the ridges, instead of the trenches to avoid damage through stagnation of water during heavy rainfall and transplanted into the trenches. This method is easy and economical but it has also its own disadvantages. Firstly, it requires a separate large seed nursery. Secondly in case of a protracted drought, irrigation requirements are pronounced and there is also the danger of soil being washed away from the top of the ridges thereby causing damage to the germinating setts.

The third method as finally developed is on the lines of the 'Japanese method of paddy cultivation'.

Seed Nursery:—Site for seed nursery should be selected at a convenient place in a plot with good drainage and a nearby source of light-watering like masonary well or hand pump. After ploughing the land, seed beds 25 ft. long 5 ft. wide and about 4 to 5 inches high are prepared with a gap of $1\frac{1}{2}$ ft. in between the beds on all sides for drainage and also to facilitate other operations like weeding etc. About one maund of well rotten and fine compost is mixed up uniformly on each bed. A thin layer of three seers fertilizer mixture

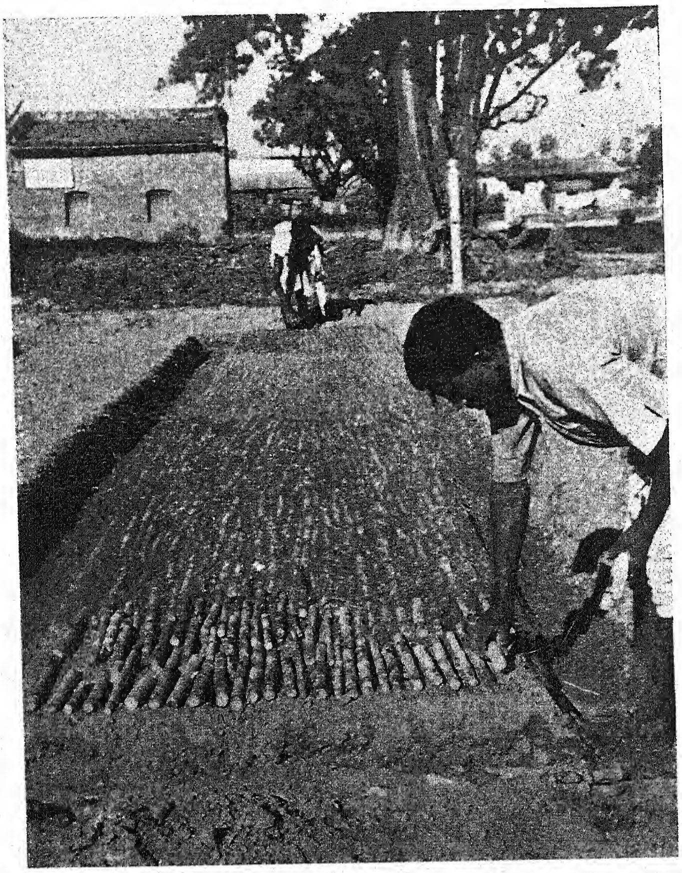


FIG. 3. Laying setts on well prepared and manured seed beds to increase rapid germination.

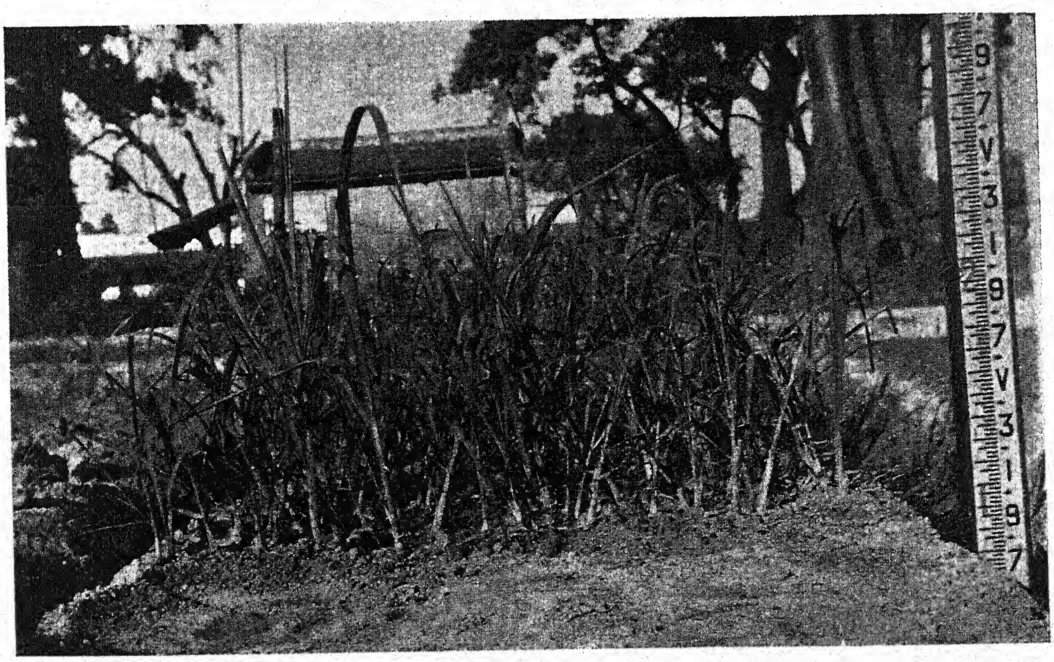


FIG. 4. Germinated setts on raised seed beds.

consisting of Ammonium Sulphate, Single Superphosphate and Potassium Sulphate in the ratio of 3:2:1 is applied to each bed. In cases of termite infested lands, a small quantity of aldrin dust (1·5 lbs./acre) should be given to ward off this attack. After mixing up the mixture smoothly with hands, the beds are levelled up. Three-budded cane setts are then placed on the beds parallel to each other with a gap of about half an inch. After slightly pressing the setts in the loose soil, the setts are covered with fine soil and compost mixture separately prepared for the purpose. The beds require light irrigation at three to four days interval, in the absence of rains. This can be conveniently done with a gardener's watering can. Further dressing up of beds with soil may be necessary in the event of heavy rainfall, when the top soil is likely to be washed off resulting in exposure of setts.

One seed bed of this size will conveniently accommodate about 800 three-budded setts, while transplanting an acre at the rate of one germinated shoot at a distance of one foot in rows and 3½ ft. between rows would require 12,500 shoots. Therefore six beds of this size would need to be arranged allowing fully for failures in germination and also for gap filling in the event of mortality after transplanting. Germination is almost complete within a week and shoots attain a height of about 9 in. to 12 in. within two to three weeks when they are ready for transplanting. It has been observed that 'shoot-roots' are ready to come out in the third week and it is advantageous to transplant seedlings before these roots actually emerge.

Layout and preparation of land:—Plots selected for monsoon planting need to be of uniform level with good drainage. Trenches should be 3½ ft. apart so as to allow room for vigorous tillering. Spacing of even 4 ft. can be allowed in comparatively heavier soils. A proper layout of the field is an important factor in view of the high incidence of monsoon rains which necessitate timely and proper drainage. Cross drains (across the trenches) are made at a distance of 33 ft. to 55 ft. depending on the slope of the field. The cross drains are connected to parallel drains made after every two acres and these latter drains open out into the main drain. Cross, parallel and main drains are stagged lower to permit adequate drainage.

After, first hoeing, press-mud compost at the rate of 150 mds./acre is applied to the trenches and mixed with the soil. The drains are kept closed, till transplantation is done to avoid loss out of manures applied as basal dressing. Further Phosphate dose at the rate of 25 lbs./acre should be applied at the time of first hoeing of trenches. Basal dressing with bulky manures is necessary to prevent loss through leaching or run of quick-acting fertilizers.

Transplanting:–Transplanting is done during the third week of planting of seed nursery. It is taken up generally on a rainy day when there is sufficient water in the trenches to make a puddle. The setts are taken out of the beds gently and each shoot is separated with a sharp cane-cutting knife and carried in baskets to the field. The soil of the trenches is puddled and a light dose of about 25 lbs. N/acre as Ammonium Sulphate or Ammonium Nitrate is applied to the soil at the time of puddling. When the trenches are ready, the shoots are planted into the trenches one foot apart. After transplanting, the trenches are kept closed so that water may not drain out. It is necessary that sufficient moisture is maintained in the trenches for about a week after transplanting. Excessive rain water, however, must be drained out through the drains provided for this purpose. It may also be noted that the sett-roots do not generally re-establish but this need not cause any worry. The shoot-roots which function throughout the plant life are ready and within 24 hours of transplanting emerge out and start their function in the soil.

Manuring:—In South India, Adsali crop requires 450 to 600 lbs. of Nitrogen per acre with very heavy irrigations. Monsoon planted cane gets considerably longer period of growth and consequently additional application of manures is quite necessary where irrigation facilities exist. The following manurial schedule has given highly encouraging results :—

(i)	Basal dressing with 150 mds. of press-mud compost	=App. 100 lbs. N
(ii)	At the time of planting Ammonium sulphate	=App. 25 lbs. N
(iii)	At the end of rainy season a mixture of Amm. sulphate and cakes in ratio of 1:2	=App. 50 lbs. N
(iv)	At the time of light earthing in December or January	=App. 25 lbs. N
(v)	Top dressing at the time of final earthing in May or 1st week of June	=App. 25 lbs. N
	Total	=App. 225 lbs. N

So far as phosphates are concerned, they are best applied at the rate of 75 to 100 lbs. in two doses one at just planting and the second in February=period next year.

Irrigation:—Rainy season planted crop requires two additional irrigations as compared to the autumn planted crop. Normally four irrigations before the break of monsoons and two post-monsoon irrigations give good result in Northern India. Where irrigation facilities are adequate, one or two extra irrigations with increased doses of nitrogen are likely to give even better results.

FIG. 5. Germinated shoots planted in well prepared trenches.

FIG. 6. Uniform and full stand of the crop planted in August.

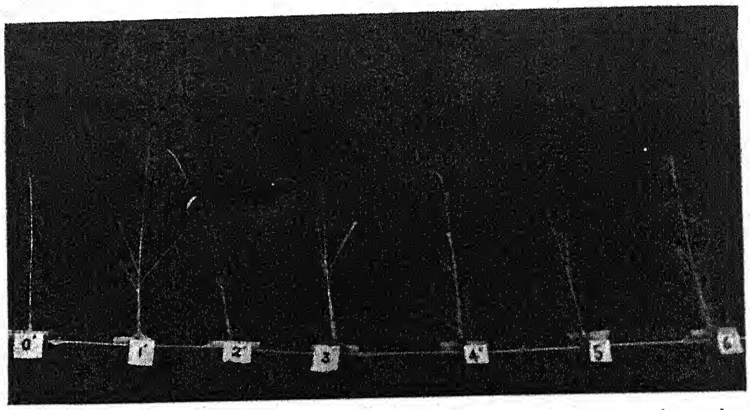


FIG. 7. Separated single-eyed shoots for transplanting in well prepared trenches.

FIG. 8. Raised seed beds with three-budded setts. The seed beds are five inches high and 25 ft. long and are appropriately fertilized.

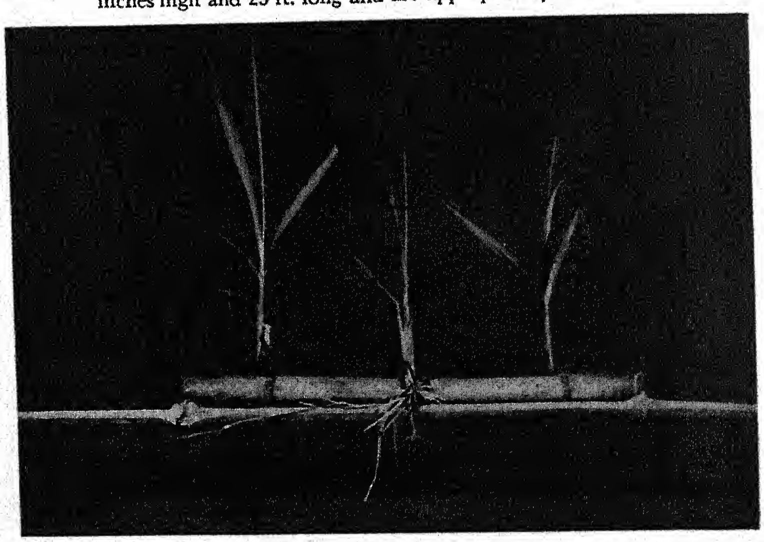


FIG. 9. A single germinated sett separately shown.

Hoeing, Weeding and Interculture:—These operations need to be carried out as in the case of either the spring or the autumn planted crop save that two to three extra light hoeings from July to October during dry spell are required. One or two weddings are required during rainy season according to the intensity of weeds. The ridges are dismantled early in January and interculture with five-tined cultivator is carried out till the beginning of April, when earthing should be done as described below.

Earthing up and Binding:—The earthing up operation is most important for the monsoon planted crop on account of its rapid and vigorous growth. Failure in proper and timely earthing results in heavy lodging of cane reduction in yield. After the fourth dose of manure, the plot is profusely irrigated to soak it thoroughly. After three or four days' time when the soil is suitable, earthing up is done with a double mould board plough (ridgers). After about a month, second earthing is done by manual labour. Some more earth is thrown over the ridges made by bullocks and closely dressed up. The third and the final earthing should be done after top dressing of Ammonium Sulphate by peg and spoon method early in July. Cane clumps are tied with green leaves at adjoining rows to prevent lodging. As much earth as possible is banked on the ridges and carefully dressed up so that earth packs off well between them. This incidentally facilities drainage and prevents gaps that may otherwise occur.

Tying Canes:—It is necessary to keep the cane erect to get continuous growth and high yield. This operation requires much more attention than the spring or the autumn planted crop as the crop has been found to attain a height of over 20 ft. A clump should be divided in two parts and tied to the corresponding halves of clumps in trenches on either side. This operation would need to be repeated twice or even thrice at appropriate intervals as the cane gains height. It is advantageous to remove dead dry leaves of the cane for ease in irrigation and preventing pest attack.

Disease and Pests

Incidence of Pyrilla was observed to be greater in rainy season planted cane due to its heavy and green foliage. Use of Endrin with Swing Fog Machine was found effective in checking the pest. Working of sprayers was found difficult due to good growth of monsoon planted crop.

Maturity and Harvesting

The monsoon planted crop matures earlier than even the Ratoon of the same variety. It is observed that the late maturing variety Co. 419 on which this experiment was conducted matured earlier than the ratoon of the same variety with 1·08 per cent more sugar during the early stages, i.e. during November and December. Average analysis data are given below:

Variety	Extraction	Juice analysis			Available Sugar % cane
		Brix	Sucrose %	Purity %	
Co. 419 July Planting	55·55	20·18	16·68	82·65	10·92
Co. 419 October Planting ..	55·47	18·95	15·48	81·69	10·05
Co. 419 Ratoon	49·97	18·82	15·25	81·03	9·84

The crop is ready for harvest from early November onwards and gradually improve still it reaches its peak about the end of February or beginning of March after which it declines.

Further trials are under way and the results will follow in due course.

Acknowledgment

The Author is indebted to Shri K. L. Khanna, F. A. Sc., Director, Sugarcane Research & Development, Bihar for guidance and constant encouragement as also for getting appropriate photographs taken by this Institute photographer to illustrate the paper. Thanks are also due to Sri B. R. Jaipuria and Sri S. R. Bhausinghka of G. S. Mills Ltd., Anandnagar for kindly providing help and facilities to conduct primary work at their CHERRI FARM. The author is also grateful to Sri J. D. Kayan, Director and Sri S. S. Kothari, General Manager of S. C. S. Co. Ltd., Samastipur for guidance and facilities for work on large scale.

APPENDIX I

Summary of Rainy Season, Autumn & Spring Cane Plantation.

Design—Randomised blocks in three replicates.
Variety—Co. 617.
Manuring—Basal dressing Pressmud compost—100 mds.
Nitrogen in 3 doses— 125 lbs.

Irrigations—7 after planting for July, Aug., Sept. & Oct.
6 after planting for Jan. and February.

Sl. No.	Month of sowing	Date of sowing	No. of buds planted per acre	Tiller counts after two months	Tiller counts after three months	Millable stalk November	Yield of striped cane harvested in January (per acre) mds.	Average height of cane	Remarks
								ft.–in.	
1.	July	22– 7-56	12,000*	45,656	56,745	58,945	1,362·07	13 2	*(Germinated shoots)
2.	August	29– 8-56	36,000	29,960	57,942	56,886	1,283·20	12 9	
3.	September	28– 9-56	36,000	32,320	47,650	46,364	845·20	12 3	Crop suffered due to heavy rains after planting.
4.	October	26-10-56	36,000	38,568	51,960	52,218	976·15	11 0	
5.	January	22– 1-57	36,000	32,353	40,930	41,455	832.39	9 6	
6.	February	24– 1-57	36,000	30,261	36,852	35,754	721·30	9 0	

APPENDIX II

Juice Analysis of Sugarcane Co. 617 July Planting in Chahri Farm.

Variety Co 617

Sl. No.	Date of juice analysis	Weight of sugarcane Md. Sr. Ch.	Number of cane sticks	Extraction per cent	Juice analysis			
					Brix	Pol.	Purity	Available sugar % cane
1.	8–11–57	0– 5-5	4	57·14	19·96	16·39	82·11	10·68
2.	3–12–57	0– 6-0	4	51·66	20·34	17·32	85·15	11·56
3.	28–12–57	0–12-8	12	44·21	22·40	19·76	88·21	13·47
4.	18– 2–58	0– 6-7	5	..	20·60	17·85	86·65	12·04

APPENDIX III

Juice Analysis Report of Sugarcane Co. 617 Planted in Different Months. Chahri Farm.

Date 20-12-57

Sl. No.	Months	Variety	Weight of cane mds. Srs. Ch.	No. of cane sticks	Extraction per cent	Juice analysis			
						Brix	Pol.	Purity	Available sugar % cane
1.	July	Co. 617	0–12–8	12	44·21	22·40	19·76	88·21	13·47
2.	August	,,	0–11–8	12	41·11	21·11	18·41	87·21	12·47
3.	September	,,	0–15–1	12	48·36	21·67	19·42	89·62	13·37
4.	October	,,	0–11–15	12	38·29	21·69	18·67	86·08	12·60
5.	January	,,	0–11–14	12	39·00	20·19	17·34	85·88	11·63
6.	February	,,	0– 8–12	12	44·44	21·61	18·99	87·88	11·98

APPENDIX IV

Available Sugar % Co. 617 Cane on Different Dates

Sl. No.	Sample	Date of analysis available sugar %		
		8–11–57	3–12–57	20–12–57
1.	Co. 617	10·68	11·56	13·47
2.	,,	9·99	11·65	12·47
3.	,,	9·80	10·67	13·37
4.	,,	11·27	11·61	12·60
5.	,,	10·55	10·87	11·63
6.	,,	9·77	10·86	12·98

UPTAKE AND UTILISATION OF NITROGEN BY SUGARCANE AS INFLUENCED BY THE TIME OF APPLICATION.*

2. EFFECTS ON THE COMPOSITION OF JUICE AND GUR QUALITY.

By

R. L. NARASIMHAM and N. V. MOHAN RAO

(Sugarcane Research Station, Anakapalle, Andhra Pradesh)

INTRODUCTION

AMONG the factors that influence the growth and maturity of a particular variety of cane, nitrogen fertilizer application is one of the most important. The composition of juice and the quality of *gur* recovered therefrom are thus naturally dependent on this aspect of cane culture. The dose, source, and the time of application of nitrogen exert their effects on the metabolism of the cane plant and determine the ultimate juice composition. Since the utilisation of nitrogen by cane is considerably influenced by the age of crop as also the climatic factors, the time of nitrogen application is of agronomic importance in the recovery of maximum sugar (or *gur*) per unit fertilizer applied. An ill-timed nitrogen application may have the dual disadvantage of improper uptake by the crop coupled with interference in its normal maturity, leading to refractory juice at harvest. The influence of the time of nitrogen application to the soil on the crop uptake in relation to yield of cane and sugar was discussed in an earlier part of this paper; the effects of the same on the ultimate composition of juice and the composition and quality of *gur* are presented in this paper.

The influence of different doses of nitrogen on the composition of juice was reported, among others, by Borden (1940, 45, 48), Evans (1936), Samuels *et al.* (1952), Rege and Basu (1948), Prasad and Srivastava (1955) and Mohan Rao and Narasimham (1951 & 1952). The general observations were a depression in sucrose and phosphate content of juice, with an increase in the reducing sugars, nitrogen, and organic non-sugars with excessive nitrogen applications. These were found to impair the quality of *gur*. The variations in the composition of juice when different forms of nitrogenous manures were applied to sugarcane were discussed by Borden (1940), Samuels *et al.* (1952) and Mohan Rao (1955). Borden (1948) studied in detail in Hawaii, the effects of the time of nitrogen fertilization to cane (at different stages of growth) on the juice composition. Nitrogen had a depressing effect on the sucrose in juice when the cane was six months old. This effect gradually levelled off by 15 months age while in subsequent months the nitrogen fertilizer application upto a limit showed even a slightly increased sucrose. The same author found an increase in the reducing sugars and moisture in the total dry weight of cane with increased nitrogen applications upto 12 months, beyond which the effects levelled down, similar being the case with the ratio of reducing sugars to sucrose (Borden, 1940).

MATERIAL AND METHODS

The details of the experiment embodying the present investigation have been given in an earlier part of this paper. The variety under study was Co. 419, planted in March and harvested at 12 months' age. Nitrogen applications were made from the source of ammonium sulphate as per the scheme given in Table I.

TABLE I

Scheme of nitrogen application

Sl. No.	Details	Nitrogen top-dressing in lb. per acre applied at				
		1½ months	3 months	4½ months	6 months	Total
1.	A*	0	0	0	0	0
2.	B	50	50	0	0	100
3.	C	50	0	50	0	100
4.	D	50	0	0	50	100
5.	E	0	100	0	0	100
6.	F	0	50	50	0	100
7.	G	0	50	0	50	100
8.	H	0	0	50	50	100

*Treatment " A " was not randomised along with others, but maintained only in separate duplicate plots; the data in the following tables refer to statistical examination of treatments B to H only, but those for " A " also have been included to give a comparative picture.

*The first part of this paper was published in the Indian Journal of Sugarcane Research and Development, Vol. III, No. 4, 1959.

Representative samples of juices were drawn from the different treatments and analysed for sucrose, glucose, and nitrogen. Trial boilings for *gur* were conducted separately for each treatment under similar conditions. The samples of *gur* were analysed for important constituents. Their keeping quality was also studied. The juices and *gur* samples were analysed according to the methods given by Brown and Zerban (1941), Fort and McKaig (1938) and Roy (1951).

Results and Discussion

(i) *Composition of juice:* The results of juice analysis for the different treatments are presented in Table II.

Table II

Effect of the time of nitrogen application on juice Composition (*Co.* 419—*March—Planted*).
(Average for three seasons, 1953-54 to 1955-56).

Sl. No.	Details	A	B	C	D	E	F	G	H	S.E.	Mean*
	I. JANUARY										
1.	Sucrose %	17·38	15·97	15·31	16·01	15·56	14·33	15·26	15·56	0·306	15·67 ±0·72
2.	Purity %	87·43	85·45	80·44	84·84	84·17	81·10	84·37	84·60	0·803	84·05 ±1·90
	II. FEBRUARY										
1.	Sucrose %	17·60	16·95	16·36	17·37	16·46	16·30	15·65	16·27	0·227	16·62 ±0·54
2.	Purity %	88·04	87·25	86·50	87·34	87·52	87·33	84·27	86·02	0·421	86·78 ±1·00
	III. AT HARVEST (MARCH)										
1.	Sucrose %	18·42	18·28	17·61	17·96	17·92	17·34	17·11	17·04	0·184	17·81 ±0·44
2.	Glucose %	0·57	0·76	1·06	0·90	0·89	1·29	1·06	1·02	0·077	0·94 ±0·18
3.	Glucose ratio %	3·09	4·40	6·02	5·01	4·97	7·44	6·20	6·00	0·467	5·39 ±1·10
4.	Purity %	88·97	89·06	86·90	88·09	89·15	87·72	87·21	86·16	0·391	87·90 ±0·92
5.	Non-protein N (mg.) ..	3·08	5·46	6·30	14·14	7·98	12·24	13·16	15·69	1·639	9·76 ±3·88
6.	Total N (mg.)	12·88	17·22	17·76	32·76	18·90	28·70	26·04	32·89	2·718	23·39 ±6·43
7.	Non-protein N as % total nitrogen	23·91	31·71	35·47	43·16	42·22	42·65	50·54	47·71	3·105	39·67 ±7·34

*With fiducial limits at P=0·05.

The data disclosed in general that higher sucrose, and purity and lower glucose ratio were recorded when the total dose of nitrogen was applied within three months. The application of a half-dose at 4½ months seemed to inevitably result in a slight depression of juice quality, further delaying resulting in practically no change. The effect of the time of nitrogen application was most characteristic in respect of the non-

protein and total nitrogen in juice. A general increase in the nitrogen content (as also in the proportion of non-protein nitrogen to the total) in juice, when the total dose of nitrogen was delayed beyond three months could be noted from the data. The highest absolute amounts of non-protein ("harmful") nitrogen in juice occurred whenever the second half-dose was given at six months, indicating that the same was not utilised to the same extent as earlier applications in the matter of plant metabolism. This constituent was significantly higher in treatment "H" than the rest. It was recorded at Pusa, Bihar (1953-54) that "harmful" nitrogen in juice was lower and *gur* quality better under September-October planting of cane than later, other factors remaining similar. Evans (1936) also found that a "late, heavy dressing of nitrogen" to cane did not produce any significant difference in the sucrose in juice as compared to the normal dressing, while there was a three-fold increase in the nitrogen content.

(ii) *Composition and quality of gur:* The results of analysis of *gur* (being average for two seasons), together with the description of the quality, in respect of the different treatments are given in Table III.

TABLE III

Effect of the time of nitrogen application on the composition and quality of gur (*Co.* 419)

(Per cent dry basis) (Average for two seasons 1954-55 and 1955-56)

Sl. No.	Treatments	Moisture % (original)	Sucrose %	Glucose %	Glucose ratio %	Ash %	Chlorine %	Total nitorgen (mg.)	Organic non-sugars %	Organic non-sugars as % sucrose	Nett rendement	Physical characteristics
1.	A ..	5·00	82·25	9·55	11·62	1·75	0·50	36·46	6·46	7·87	67·09	Bright yellow; hard; crystalline
2.	B ..	5·94	79·30	11·71	14·84	1·72	0·58	48·93	7·28	9·19	61·59	Yellowish brown; hard; crystalline
3.	C ..	6·98	78·70	12·61	16·10	1·69	0·65	51·16	7·01	8·93	59·67	Light brown; moderately hard; crystalline
4.	D ..	6·96	75·34	12·21	16·31	1·53	0·73	79·41	10·92	14·01	57·78	Brown; moderately hard; less crystalline
5.	E ..	6·08	78·72	11·70	14·87	1·55	0·62	59·04	8·03	10·20	61·60	Light brown; hard crystalline
6.	F ..	5·72	74·34	12·46	16·71	1·66	0·67	85·78	11·55	15·62	56·07	Brown; moderately hard; less crystalline
7.	G ..	7·53	76·34	11·80	15·44	1·56	0·67	72·51	10·31	13·51	59·10	Light brown; moderately hard; less crystalline
8.	H ..	7·83	74·22	12·73	17·19	1·61	0·70	101·57	11·45	15·41	55·85	Brown; less hard and crystalline
	S.E. ..	0·344	0·995	0·361	0·614	0·030	0·003	7·670	0·757	1·106	1·293	
	Mean* ..	6·51 ±0·81	77·40 ±2·35	11·85 ±0·85	15·39 ±1·45	1·63 ±0·07	0·64 ±0·01	66·86 ±18·14	9·13 ±1·79	11·84 ±2·62	59·84 ±3·06	

*With fiducial limits at P=0·05.

The *gur* quality was better when the first half-dose was given within three months and the fertilizer application completed by 4½ months. The quality, particularly the hardness and crystalline structure, was adversely affected when the second half-dose of nitrogen was delayed upto six months. The glucose ratio, organic non-sugars (and ratio of the same to sucrose) were higher, and sucrose-content lower for the delayed applications, the maximum effects being observed when the nitrogen dose was given in two halves at 4½ months and six months. The effects on the ash and chlorine content of *gur* were not pronounced. The

most marked effects were noticeable, as in the case of juices, in respect of the nitrogen content of *gur*, applications of nitrogen beyond three months resulting in a significant increase of the same in *gur*. Application of a nitrogen-dose at as late as six months invariably resulted in higher amounts of the same in *gur*, obviously through higher soluble nitrogen in juice. The role of soluble nitrogenous compounds in cane-juice clarification in raw-sugar manufacture, particularly on colour formation has been discussed by Honig (1951). The detrimental effects of the same on sucrose-recovery can be assessed from the lower rendement figures recorded under such conditions.

(iii) *Keeping quality of gur:* Representative samples of *gur* from the different treatments were stored in bottles for study of keeping quality. The samples were again analysed for sucrose, glucose and its ratio to sucrose, at the end of the monsoon period, and the extent of deterioration under the various treatments studied. The data are presented in Table IV.

TABLE IV

Keeping quality of gur samples (Mean for two years)

(Analysis after deterioration)

Sl. No.	Treatments	Fall in sucrose as % over original	Increase in glucose as % over original	Increase in glucose ratio as % over original	Notes on Keeping quality
1.	A*	3·21	3·25	3·68	Kept well.
2.	B	4·92	6·15	11·61	Kept well.
3.	C	6·25	10·26	17·67	Slight softening.
4.	D	9·05	42·63	53·20	Considerable softening and darkening on storage.
5.	E	1·52	1·53	1·07	Kept well.
6.	F	2·82	23·13	19·83	Softening and slight darkening on storage.
7.	G@	..	..	..	..
8.	H	8·68	43·13	54·74	Considerable darkening; became soft and semi-solid; worst keeping quality.

*Data for one year only.
@Not analysed.

The data indicated that application of the second half-dose at or after 4½ months exerted detrimental effect on the keeping quality when the entire application was made after three months; in contrast, the samples of *gur* from treatments which received the entire dose within three months showed the best keeping quality, having the lowest fall in the sucrose and increase in glucose and glucose ratio on storage. The worst keeping quality was exhibited by *gur* from treatments for which the second half-dose was delayed till six months; these showed considerable increase in glucose ratio on storage. The association of higher nitrogen-content of *gur*, as also glucose and organic non-sugars in same with poorer keeping quality was brought out by the data. According to Spencer and Meade (1951), there is a direct relationship between the nitrogen-content of "raw sugar" and the colour increase during storage, but the nitrogen does not seem to affect the original colour. The poorer keeping quality of *gur* from cane grown under water-logged conditions for some period, has been ascribed by Mohan Rao and Reddy (1951) to higher soluble nitrogen in juice passing on into *gur;* Mohan Rao and Narasimham (1951) reported the association of poorer keeping quality of *gur* with higher glucose, nitrogen, and organic non-sugars.

The need for early application of nitrogenous fertilizers to sugarcane for better keeping quality of *gur* is indicated from the studies.

Summary

The influence of nitrogen applications in the form of ammonium sulphate, given to sugarcane at different stages of growth on the composition of juice, and composition and keeping quality of *gur* are discussed in the paper.

Better juice quality was in general recorded when the total dose of nitrogen was applied within three months; there was slight depression of the same when a half-dose was given at 4½ months. An increase in the non-protein and total nitrogen in juice resulted when the entire nitrogen application was made after three months, the highest amounts corresponding to application at six months. The quality of *gur* was better when a half dose was given before three months, and the manuring completed by 4½ months. Delaying the nitrogen application beyond this stage increased the glucose ratio, organic non-sugars, and nitrogen content of *gur*, the ash and chlorine being unaffected. The highest figures for the former were recorded when the second half dose of nitrogen was delayed till six months, *gur* from such treatment exhibiting the worst keeping quality on storage.

Under the conditions of the tract, it is thus advisable to complete the nitrogenous manuring to cane not later than 4½ months with the application of the first half dose within three months, in order to secure better quality *gur*.

Acknowledgment

The work reported in this paper was conducted in a scheme of research on sugarcane partly financed by the Indian Central Sugarcane Committee, New Delhi, to whom our thanks are due.

REFERENCES

Annual Report of the Central Sugarcane Research Station, Pusa (Bihar), 1953-54.
Borden, R. J. (1940). *Hawaii Plant Rec.*, **44**: 81-88.
———— (1945). *Ibid.*, **49**: 259-312.
———— (1948). *Ibid.*, **52**: 1-51.
Brown, C. A. and Zerban, F. W. (1941). Physical and chemical methods of Sugar analysis (John Wiley & Sons, New York).
Evans, H. (1936). Bull No. 10, Sugarcane Research Station, Mauritius, 10.
Fort, C. A. and Mckaig, N. (1938). Tech. Bull, No. 688, U. S. ,Department of Agriculture, Washington, D.C.
Honig, P. (1951). Principles of Sugar Technology (Elsevier Publishing Co., Amsterdam).
Mohan, Rao, N. V. and Narasimham, R. L. (1951). *Proc. 1st Bienn. Conf. Sug. Res. Workers* in Indian Union, Coimbatore, Part II, 143-51.
Mohan Rao, N. V. and Reddy, D. A. (1951). *Ibid.*, 152-56.
———— and Narasimham, R. L. (1952). *Madras Agric. Jour.*, **39**: 243-55.
———— (1955). *Proc. 2nd Bienn. Conf. Sug. Res. & Dev. Workers* in Indian Union, Jallundur: 492-99.
Prasad, K. and Srivastava, D. P. (1955). *Ibid.*, 584-96.
Rege, R. D. and Basu, J. K. (1948). Sugarcane Research in Bombay-Deccan, 1932-44. (Government Press, Bombay).
Roy, S. C. (1951). Monograph on the *Gur* Industry of India (Indian Central Sugarcane Committee, New Delhi).
Samuels, G. *et al.*, (1952). *Jour. Agric. Univ. of Puerto Rico*, **36**: 203-29; *Ibid.*: 230-39.
Spencer, G. L. and Meade, G. P. (1951). "Cane-Sugar Hand Book" (John Wiley & Sons, New York).

PHOSPHATE FERTILISING OF SUGARCANE IN MYSORE.

By

B. V. VENKATA RAO and B. BHEEMASENA RAO

(Department of Agriculture, Bangalore, Mysore)

GENERAL

MYSORE is climatically ideally suited for sugarcane cultivation. Every year, over fifty thousand acres come under sugarcane, both under channel and tank irrigation. The crop is intensively cultivated and irrigation is done by water lifts from wells at great expense at times when there is scarcity of water. The crop is intensively manured both with bulky manures and artificials. The ryot puts in maximum effort and he is quite certain of good returns, when he delivers the cane to the sugar factory as in the Mandya areas.

Mysore Department of Agriculture has been conducting manurial experiments for the past 30 years on various experimental farms representing the major soil types, with the object of arriving at an optimum and economic dose of manures for sugarcane in the various regions. While nitrogen is mainly responsible for increasing yields of cane, phosphorus and potassium are necessary from the standpoint of physiological and maintenance of soil fertility. Since an economic return is the immediate interest, the attention paid to phosphorus and potassium, the two major elements, besides nitrogen in crop nutrition, is not commensurate with the very important role they are known to play in plant growth. In spite of such an attitude generally prevailing, the Department has conducted several experiments on the application of phosphatic and potassic fertilisers and included a minimal dose of them in the fertiliser recommendations for sugarcane and various other crops. In this paper the results of the experiments with phosphate fertilisers for the past 25 years are presented.

EXPERIMENTAL RESULTS

Babbur Farm represents the base saturated black soil region in the Northern part of the state. The Visveswaraiah Canal Farm represents the sandy loam soils brought under irrigation by the Krishnaraja sagara reservoir and the Hebbal farm represents the tank irrigated areas in Bangalore in the red soil region. The physical and chemical composition of the soils are given in Table I.

TABLE I

Mechanical and Chemical Composition of the soils of the Experimental farms.

Sl. No.	Name of the farm	Coarse Sand %	Fine Sand %	Silt %	Clay %	*pH*	N%	Total P_2O_5 %	Available P_2O_5 %	Ex. CaO %
1.	A.R.S. Hebbal Farm Bangalore ..	23·00	58·80	4·51	10·05	7·0	0·053	0·05	0·002	0·21
2.	A.R.S. (Visveswaraiah Canal Farm)—Mandya	40·90	34·00	4·60	17·75	6·5	0·049	0·025	0·0014	0·12
3.	A.R.S. Babbur—Hiriyur	5·05	57·14	11·44	24·38	8·5	0·040	0·0029	0·0054	0·27

A. The effect of incremental doses starting from 45 lbs. P_2O_5 was studied and the results are presented in Table II.

These treatments are over a basal dressing of two tons of green manure, ten tons of F.Y.M. and a common dose of 200 lbs. of nitrogen. The responses to applications of Superphosphate (Table II) are fairly consistent and the increases in yield beyond the 45 lbs. P_2O_5 level are neither marked nor commensurate with the increase in dose of P_2O_5.

These variations in P_2O_5 are over a common dose of 200 lbs. of N and basal dressing, of bulk manures consisting of two tons of green manure and ten tons of F.Y.M. It is seen that there are responses to the different forms of phosphatic fertilizers. (Table III).

TABLE II

Yield data on the effect of incremental doses of P_2O_5 for Sugarcane at Babbur Farm between the years 1929-34

(Yield of cane in tons per acre)

Sl. No.	Treatments	1929-30	1930-31	1931-32	1932-33	1933-34	Average
1.	Control	23·8	25·8	24·1	22·8	21·9	23·7
2.	45 lbs. of P_2O_5 as superphosphate ..	27·5	27·5	27·8	26·5	27·0	27·3
3.	67.5 lbs. of P_2O_5 as superphosphate ..	28·1	27·4	29·6	28·5	29·8	28·7
4.	90 lbs. of P_2O_5 as superphosphate ..	31·6	25·6	29·6	29·3	28·6	28·8
5.	135 lbs. of P_2O_5 as superphosphate ..	25·9	28·3	25·2	25·2	29·3	28·2

TABLE III

Yield data on the comparative performance of different phosphatic fertilizers at Babbur Farm between 1931-34

Sl. No.	Treatments	1931-32	1932-33	1933-34	Average
1.	Control	26·4	22·5	19·6	32·8
2.	50 lbs. of P_2O_5 as superphosphate ..	34·2	30·4	26·5	30·4
3.	50 lbs. of P_2O_5 as Amophos ..	31·8	26·6	24·7	28·2
4.	50 lbs. of P_2O_5 as Niciphos and Super	33·0	26·3	21·0	28·0

B. Another experiment was conducted at Visveswaraiah Canal Farm representing the sandy loam soils brought under irrigation after the construction of Krishnarajasagar reservoir. The yield figures are given in Table IV.

TABLE IV

Yield of cane in relation to the doses of Superphosphate—V. C. Farm—1935-36

Sl. No.	Treatments	Yield of cane in tons/acre
1.	Super at 1 cwt. per acre ..	30·8
2.	Super at 2 cwt. per acre ..	28·45

Phosphate was given over a basal dressing of six tons of compost and a common dose of 200 lbs. of N. It is seen that there is no increase in yield of cane with the increase in the dose of phosphate.

C. In 1937-38 another experiment was conducted at V.C. Farm, to study the optimum combination of N and P_2O_5 over a basal dressing of potash for sugarcane and the data are given in Table V.

The differential treatments are over a basal dressing of six tons of compost and a common dose of 100 lbs. K_2O. Results from Table V indicate that increases in dose of N must go with proportionate increase in dose of P_2O_5. However, the increases in yield due to increase in the doses of N or P_2O_5 are not significant.

Another experiment to ascertain the optimum dose of P_2O_5 for cane at V.C. Farm was conducted during 1937-38, and the results are tabulated in Table VI.

TABLE V

Yield data on the variations in the dose of N and P_2O_5 for cane at V.C. Farm, 1937-38

Sl. No.	Treatments	Yield of cane in tons per acre
1.	180 lbs. of N + 45 lbs. P_2O_5 ..	20·6
2.	180 lbs. of N + 90 lbs. P_2O_5 ..	22·2
3.	225 lbs. of N + 45 lbs. P_2O_5 ..	24·6
4.	225 lbs. of N + 90 lbs. P_2O_5 ..	26·6
5.	270 lbs. of N + 45 lbs. P_2O_5 ..	26·6
6.	270 lbs. of N + 90 lbs. P_2O_5 ..	29·6

F—not significant.

TABLE VI

Experiment on the optimum dose for cane at V.C. Farm, 1937-38

Sl. No.	Treatments	Yield of cane in tons per acre
1.	Super-phosphate at 1 cwt. per acre	35·0
2.	-do- at 1½ cwt. per acre	29·5
3.	-do- at 2 cwt. per acre	24·9
4.	-do- at 3 cwt. per acre	21·5

F—not significant.

The treatments are over a basal dressing of six tons of compost and 200 lbs. of N. This experiment reveals a tendency for decrease in yield with increasing doses of P_2O_5. It may be perhaps due to the lack of proportionate increase in dose of N.

D. During the latter part of the last war and during post-war period there was considerable shortage of superphosphate and bone meal was freely recommended for use as a source of phosphorus to paddy, Sugarcane and other crops and experiments were laid out to assess its value as a source of phosphorus for cane in combination with various nitrogen supplying materials.

TABLE VII

Yield data on the use of Organic source of P with Organic and mixed organic source of N during 1946-47

(Yield of cane in tons per acre)

Sl. No.	Treatments	Hebbal farm	Babbur farm	V.C. Farm
1.	N wholly as groundnut cake + 25 lbs. of P_2O_5 as bone meal	61·38	14·05	30·74
2.	N½ as G.N.C. and ½ as $Am_2 So_4$ + 25 lbs. of P_2O_5 as bone meal	51·06	21·21	22·57
3.	N¾ as G.N.C.,¼ as $Am_2 So_4$ + 25 lbs. of P_2O_5 as bone meal	54·26	15·82	23·28

F—not significant for any of the experiments.

Treatments are over a basal dressing of 3,000 lbs. of green manure and three tons of compost. The dose of N being 200 lbs. Yield figures in Table VII indicate that P_2O_5 as bone meal gives better returns when the N supplied along with it is preponderantly in the organic form.

E. With a view to get better and definite crop responses to application of phosphatic fertiliser, the Department has been working for the past eight years on suitable techniques of phosphate fertilization by which the fixation of soluble phosphate in the fertilisers to insoluble forms on application to soil is minimised. Improved methods such as placement of phosphatic fertilisers in lands at depths three to six inches below the seed through a simple seed drill, application of phosphates to a leguminous green manure crop preceding the main crop, composting phosphate with farm yard manure and application of phosphate along with green leaf manure are being suggested for adoption on a field scale. To a certain extent some of the methods have become a field practice. The results of some of the experiments on placement of phosphatic fertilisers at depths in furrows for sugarcane are given in Table VIII.

TABLE VIII

Experiment on the placement of phosphates for Sugarcane

(Yield of cane in tons per acre)

Sl. No.	Treatments	Hebbal Farm				Babbur Farm			V.C. Farm
		1949–50	1951–52	1952–53	1953–54	1951–52	1952–53	1954–55	
1.	Super at 2 Cwt. per acre at surface	21·17	35·44	14·04	24·24	22·3	14·83	28·3	26·48
2.	Super at 2 Cwt. per acre at 3″ depth	28·75	35·51	14·79	32·21	23·65	15·67	30·6	30·04
3.	Super at 2 Cwt. per acre at 6″ depth	26·15	35·72	15·50	30·70	21·8	15·25	..	..

F—not significant for any of the experiments.

Though there is no statistical significance, the yield figures in Table VIII reveal a marked general tendency towards better yields when phosphates are applied at depths of three to six inches below the surface.

SUMMARY

In this paper results of several experiments conducted in Mysore State for the past 25 years at Babbur Farm, Visveswaraiah Canal Farm and Hebbal Farm respectively on the response of Sugarcane to phosphatic fertilisers, are presented. In the earlier years the experiments were directed towards fixing an economic and optimum dose of P_2O_5. It was found that responses to a dose above 45 lbs. level were not appreciable and even at this level the responses were neither definite nor consistent. Various forms of phosphate such as " Amophos," " Niciphos " were also tried. There were also indications that increases in dose of N needed proportionate increase in dose of P_2O_5. Bone meal gave better results in combination with organic sources of N. Experiments on the placement of phosphates at depths of three to six inches in furrows below the seed set indicate consistent trends towards increased yields.

REFERENCES

Mysore State Department of Agriculture, Manures and Fertilizers (1955). A manurial schedule for various crops in Mysore—Chemistry Series.

——— *Ann. Report Div. Agr. Chem.* for the 'years 1930-55'.

SUGAR RECOVERY PER CENT OF SUGAR FACTORIES IN MADRAS STATE—A CRITICAL STUDY.

By

P. S. Sanjeevi

(Central Sugarcane Research Station, Cuddalore, Madras)

Introduction

Of the existing five sugar factories *in Madras State, the recovery data of the three sugar factories at Nellikuppam, Pugalur and Madura are reviewed in this paper with a view to assess the relative importance of each zone in this State for getting a high sugar recovery from cane and also to study the possible agricultural factors that are associated with it. The factory at Pettaivaithalai in Trichy district was commissioned during August 1958 while the other at Vadapathimangalam in Tanjore district started production during 1957 and hence they are not considered in this paper.

Importance of sugar recovery per cent

Sugar recovery is defined as the number of tons of sugar produced per hundred tons of cane crushed and it determines the number of tons of cane required to produce one ton of sugar. During 1956-57, the average recovery per cent of Madras State is reported to be 9·15 per cent which indicates that nearly 11 tons of cane were utilised for processing one ton of sugar. This is rather high as compared to 6·8 tons of cane required to produce one ton of sugar in Australia and is satisfactory when compared to Indian average of 10·3 tons of cane needed to manufacture the same quantity of sugar. Thus the higher the sucrose content of cane, the lesser will be the quantity of raw material necessary to produce the same quantity of sugar and the recovery obtained in a zone is a measure of quality of cane cultivated in the zone. Further the recovery per cent of a sugar factory may largely determine the profit and bring extra income to the cane grower in shape of bonus over and above the minimum cane price fixed by the Government as profit-sharing scheme between miller and grower based on recovery per cent may also come into practice in our country in due course as is prevalent in foreign countries.

The higher recovery per cent will also reduce the cost of production of sugar which will make it possible to place Indian sugar at cheaper rates in international market as shown below and will serve as source of much-needed foreign exchange.

Quantity of cane crushed	Recovery %	Sugar produced	Cost of cane @ Rs. 40/- per ton	Cost of production of 1 ton of sugar
100 tons	9	9 tons	Rs. 4,000/-	Rs. 444·40
100 tons	10	10 tons	Rs. 4,000/-	Rs. 400·00

When recovery per cent is increased by one per cent for the same quantity of cane crushed, under the existing system of payment, the cost of production of sugar per ton will be less as the total cost incurred towards the purchase of the raw material will be the same in both the cases. If the basis of fixing sugar price has any relation to the cost of raw material utilised, higher recoveries will necessarily result in lowering the price of sugar.

The payment of cane on Sisma formula already tried by sugar industry takes into account the recovery per cent obtained in a factory. Before long, the payment of cane involving the quality of cane in one way or other may be adopted as the same is contemplated by all interested in sugar industry.

Sisma Formula

This formula has been evolved by South Indian Sugar Mills Association. The price payable by factories for cane to be calculated on the nett amount realised by individual factories from the sale of sugar and on the actual recovery obtained by individual factories is as follows :—

Sugar price per ton	*Cane price*	
At and above Rs. 940/-	70 per cent.	Nett amount realised by individual factories from the sale of sugar divided by the actual number of tons canes used in the production of one ton of sugar (i.e. average recovery per cent)
At Rs. 840/-	67 ,,	,,
At Rs. 740/-	64 ,,	,,
At Rs. 640/-	61 ,,	,,
At Rs. 540/-	58 ,,	,,
At Rs. 440/-	55 ,,	,,
At Rs. 440/-	52·5 ,,	,,

The *average recovery per cent* is a percentage of sugar produced to cane crushed over the entire season in the year.

The *average sugar price* is the price realised from the sale of all sugar sold during a particular period following the season by number of tons sold after deducting excise duty and other taxes.

The average Indian sugar recovery per cent is 9·72 during 1956-57 which is low as compared to 14 per cent recovery obtained in Australia which is the highest in the world. The average sugar recovery per cent of Madras and other states in India for nine years are presented in Table I for comparison.

TABLE I

Sl. No.	Name of State	Recovery %
1.	Madras	9·14
2.	Uttar Pradesh	9·70
3.	Bihar	10·03
4.	Bombay	11·53
5.	Andhra Pradesh	9·47
6.	Punjab	9·55
7.	Madhya Pradesh	9·37
8.	Mysore	9·99
9.	Kerala	8·13
10.	Orissa	8·79
11.	West Bengal	10·44
	All India	9·88

In respect of sugar recovery per cent the Madras State compares favourably with most of the other Indian States except Bombay. Bihar, U.P., Mysore and West Bengal.

Sugar Recovery per cent in Madras State

The average sugar recovery per cent for the three factories in Madras state is given in Table II for a period of eight years (Fig. 1) (Data compiled from Annual report of Sugarcane Development Scheme Madras 1950 to 1956).

FIG. 1.

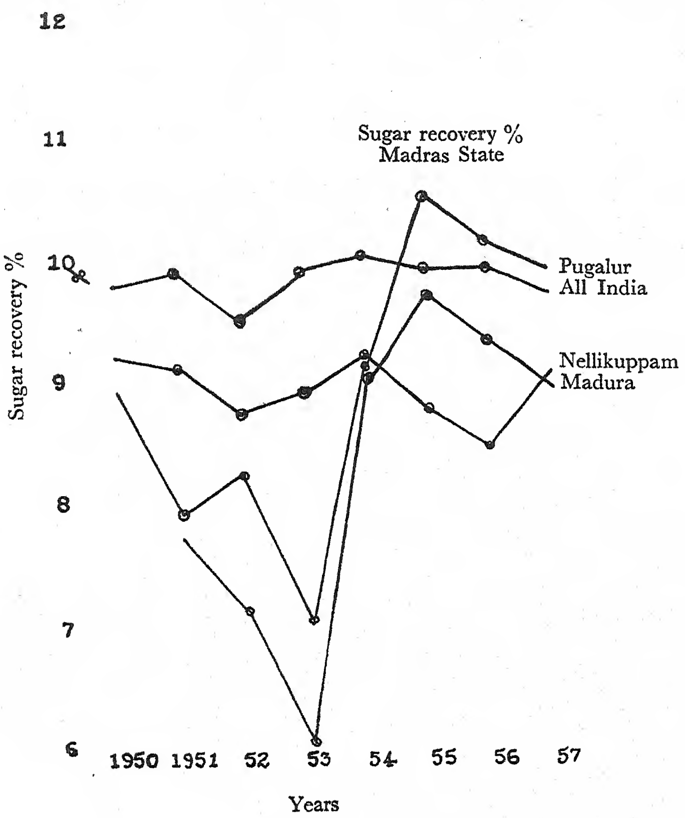


TABLE II

Year	Recovery per cent					All India Average	Madras State Average
	Nellikuppam Main season	Pugalur		Madura			
		Main season	Special season	Main season	Special season		
1949–50	9·25	8·97	9·06	..	..	9·88	9·60
1950–51	9·11	7·96	8·00	7·73	..	9·99	9·35
1951–52	8·73	8·20	8·07	7·14	..	9·59	8·65
1952–53	8·91	..	..	6·04	..	9·96	8·84
1953–54	9·22	9·11	..	9·09	..	10·07	9·20
1954–55	8·75	10·52	..	9·73	..	9·93	9·24
1955–56	8·46	10·16	9·71	9·30	..	9·93	8·85
1956–57	9·00	9·93	9·31	8·90	7·96	9·72	9·16
Average ..	8·9	9·2	8·8	8·2	7·9	9·9	9·11

In Madras State, the highest recovery is recorded in Pugalur Zone. When the performance of individual factories is considered, the average recovery at Pugalur is slightly better than Nellikuppam. The Madura Sugar Factory records low recovery as compared to both Nellikuppam and Madura. The

potentiality of each zone differs in giving a high recovery per cent. Further the main season recovery is higher than the special season, both at Pugalur and Madura. Between Pugalur and Madura, the former records an increase of 1·03 per cent recovery for main season and 1·35 per cent for special season.

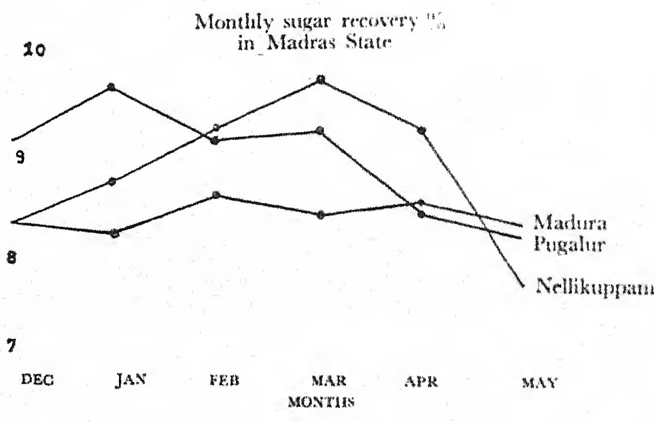
TABLE III

Monthly recovery per cent of different factories in Madras State

Month	Average Sugar Recovery %		
	Nellikuppam	Pugalur	Madura
December	8·47	9·26	8·40
January	8·83	9·71	8·39
February	9·36	9·23	8·70
March	9·80	9·33	8·57
April	9·36	8·56	9·64
May	7·83	8·30	8·42
Average	8·9	9·1	8·5

The above data indicate that for Nellikuppam, recovery is not satisfactory at the commencement of the season when compred to Pugalur, though it is on par with Madura recovery. Improvement in recovery is noticed from December-March for all the three factories. The outturn is not satisfactory for late crushings at Pugalur while a uniform level of recovery is noticed in case of Madura of all the months of crushing. (Fig. 2)

FIG. 2.



DISCUSSION

It is to be borne in mind that the recovery per cent of these three factories are not strictly comparable as the varietal position is not the same in all these zones. Neither a common harvesting schedule nor the same crushing duration is assumed in considering the available data for comparison. The particulars gathered will serve at best as an indication only and it seems probable that each zone has an inherently differing potentiality in giving a good recovery. The data has to be reviewed and analysed against this background.

The sugar recovered in a factory is dependent upon many factors of which varietal position, duration of crush and seasonal factors are considered most important. While the first two factors are controllable,

the seasonal attribute is beyond human approach and it is of primary importance to locate factories in areas where natural facilities exist for obtaining high recoveries. Assuming uniform factory efficiency, the factors which are primarily considered as responsible for fluctuations in recovery are presented here.

Sugar recovery in relation to season

The climatic factors which predominantly influence the formation and accumulation of sucrose in sugarcane should be *favourable* for cane cultivation. Temperature, rainfall, humidity sunshine, wind etc. constitute the major climatic factors which are collectively known as season. A dry warm weather during day and cold night at the maturity phase with fair and uniform distribution of rain during its active grand growth period is considered optimum for producing high quality cane. The prevalence of wet weather during harvesting stage may keep the vegetative phase active delaying maturity. The rainfall data for all the regions are furnished from November to April during and preceding harvest season in Table IV.

TABLE IV

Rainfall in inches

Year	Nellikuppam	Pugalur	Madura
1950–51	16·26	..	16·75
1951–52	39·31	7·84	11·34
1952–53	17·95	6·44	3·28
1953–54	15·30	3·66	5·91
1954–55	12·67	3·10	1·91
1955–56	14·25	8·67	9·18
1956–57	18·10	5·45	16·31
Average	19·12	5·02	9·24

The data indicate that the mature cane fit to be harvested receive considerable amount of rain during North-East monsoon in November-December in Nellikuppam area. The wet weather and excessive rains are responsible for giving a low recovery at the start as compared to other two areas where precipitation received is relatively small. Thus the region selected for location of sugar factories should be free from heavy rainfall during its harvest period. The above view is also shared by duToit (1958) who places climatic factors, particularly wet weather, above all others as mainly responsible for sucrose fluctuations in canes. The same author attributes peak sucrose accumulation to a cold season, but more often to a dry season. Considerable rainfall preceding harvest and appreciable temperature during harvesting stage and low total hours of sunshine during its life cycle, are said to cause decline in sucrose content.

Recovery per cent in relation to varieties

The varietal distribution more than anything else in a factory zone will largely control the sugar recovery per cent. In Pugalur sugar factory zone the major variety grown is only Co. 419 and bulk of the planting is done during February and March. This being a late season variety, does not give a satisfactory quality at the beginning of the crushig in December or January resulting in poor recovery. Similarly at the end, over-matured canes get into the crush giving a low recovery in April and May. In order to overcome this and to prolong the crushing season fairly with good recovery, a varietal combination consisting early, mid-season and late varieties is recommended for this zone. The area under Co. 449 is gradually expanding and this is already reflected in better recovery. The recovery per cent at this factory seems to be capable of further improvement if a suitable varietal programme is followed in this tract. As between Pugalur and Madura, the recovery per cent is better at the former zone as compared to Madura for the same variety and it appears that Pugalur is more advantageously situated in realising a high recovery than Madura.

As compared to this, the varietal position in Nellikuppam zone is very interesting. The three varieties Co. 281, Co. 349 and PoJ 2,878 which were considered satisfactory for its sucrose content and grown during

earlier years have now been completely replaced by high sugared varieties like Co. 527 and Co. 449. The variety Co. 419 which is a dominant variety in other two factories is occupying a negligible area in this zone. The reason for this when analysed will indicate that Co. 419 under conditions obtaining in this zone will give a poor recovery. The recovery is related to commercial cane sugar per cent in cane while C.C.S. in tons per acre attributed to any variety takes both yield and quality of cane into consideration. So long as the payment of cane is made on weight basis without any reference to its sugar content, the attribute of more sugar per acre alone without satisfactory quality may not make the variety eligible for large scale cultivation in factory areas lest low recovery should result. Even the latest available data show the superiority of " wonder cane " Co. 419 both in respect of yield and C.C.S. in tons per acre, but it has not made any headway due to its unsatisfactory sucrose content in this zone. This aspect of varieties need to be clearly studied before its spread is contemplated in a factory zone. With a varietal schedule, *Adsali* cropping and high sucrose varieties like Co. 449 and Co. 527, this factory is only able to maintain its recovery per cent and not even slight increase is noticeable as compared to its earlier recovery. The possibility of improving the recovery per cent still further in this zone offers a challenge to the research worker in the face of unfavourable climatic factors. Varietal selection and cultural improvement by way of following a rational harvesting schedule seem to offer fruitful lines of work in this area.

Sugar recovery in relation to manuring

The per cent of sugar recovery is likely to be affected by the manurial dose applied to the cane crop in the tract. As the cane is purchased on weight basis, the present tendency of the grower is to push up yield with high dose of manuring at the cost of quality of cane. The research work done so far on this aspect show that manurial needs of a zone should be decided with reference to the variety grown and soil type etc. Parthasarathy (1956) opines that manure is better utilised in sandy and loamy soils as compared to clayey soils. As higher dose of nitrogen will depress the juice quality under garden land or light soil types where the utilisation of manure applied is more, a lesser dosage is to be recommended if good quality cane is the objective. In Nellikuppam factory zone where garden land cultivation is predominant, a dosage of 250 N is advocated per acre. Ryots are prone to apply even upto 350 lbs. N per acre which may give increased tonnage of poor quality cane under conditions such as delayed application. The heavy manurial schedule adopted under such soil types may also contribute its share in pulling down the recovery at this zone. The manurial dose needs to be fixed up with reference to major soil types.

Apart from the above three major factors there are other causes which may possibly influence the recovery per cent. The possibilities of other factors such as excessive or inadequate irrigation, incidence of pests and diseases, and delayed applications of manure etc., affecting the sucrose content of cane, consequently modifying the sugar recovery per cent cannot also be ignored.

Summary and Conclusions

The average sugar recovery per cent of the three sugar factories in Madras state have been reviewed and compared with other states in India. The recovery of Nellikuppam Sugar Factory (8·9 per cent) is slightly less than Pugalur (9·2 per cent) and comparatively better than Madura (8·2 per cent) though rich cane varieties like Co. 449 and Co. 527 are grown in the former zone. The season seems to play an important role in growing canes rich in sugar. The location also determines a second season of crushing during August-October though the recovery obtained in special season is lower than the main season which again emphasizes the effect of season on quality. Selection of suitable varieties for Nellikuppam zone to overcome the unfavourable climatic factors and a proper varietal planning in case of other two factories appear necessary in pushing up the present recovery of Madras state as the possibility of obtaining sugar recoveries over 10·5 per cent has been indicated in Pugalur zone.

Acknowledgment

I thank very much Sri C. R. Thiruvengadam B.Sc. (Ag.), Assistant Agronomist, Central Sugarcane Research Station, Cuddalore, for having gone through this paper and made valuable suggestions.

REFERENCES

Annual Progress Report of Sugarcane Development Scheme, Madras (1950-51).
——— (1951-52).
——— (1952-53).
——— (1953-54).
——— (1954-55).
——— (1955-56).
Indian Sugar, **8** (1): 117.
DuToit , J. L. (1958). Sucrose formation and concentration in sugarcane—South *African Sugar Journal*, **43** (3): 205.
Parthasarathy, S. V. (1956). Problems of Sugarcane and Sugar Industry in India.

SOME IRRIGATIONAL STUDIES WITH IMPORTANT SUGARCANE VARIETIES IN THE PUNJAB

By

HARBANS SINGH, PURAN ANAND ADLAKHA and M. M. SINGH THAKUR

(*Sugarcane Research Station, Jullundur, Punjab*)

INTRODUCTION

IN the matter of cane acreage, Punjab occupies second or third position in different years amongst the important cane growing States in the country. Cane area in the State in different years has varied between 3·5 and 4 lakh acres. On an average 70 per cent of this constitutes irrigated area. The irrigational facilities during summer are not adequate in various tracts. For rainfed area and where irrigational facilities are insufficient, varieties with less water requirements are needed. To assess the behaviour of the important cane varieties under different conditions of irrigation, the above studies were taken up at the Sugarcane Research Station, Jullundur. Alongwith the field trials, morphological, physiological and anatomical studies were also carried out to ascertain the characters responsible for greater vegetative growth even under restricted irrigational conditions.

The results of irrigational experiments described in the annual reports of the Sugarcane Research Station, Lyallpur (1934-39), the Sugarcane Research Station, Jullundur (1946-49), the Sugarcane Research Station, Pusa, Bihar (1936-40), and the Sugarcane Research Station, Shahjahanpur, U.P. (1953-54), bring out the beneficial effect of irrigations on growth and final yield of cane. Harbans Singh *et al.* (1951) showed differential behaviour of different varieties to irrigations. Martin (1920), Mameli (1926), Khanna and Raheja (1938) and Rao (1950) have tried to correlate the morphological, physiological and anatomical characters with the drought resistance of different crop varieties.

MATERIAL AND METHOD

These experiments during 1952-53 were conducted on the sandy loam soil of the Research Station. The physical composition was:—

TABLE I

Type of soil	1st foot		2nd foot	
	Clay+silt	Fine+ coarse sand	Clay+silt	Fine+ coarse sand
Sandy loam	46·00	54·00	45·65	54·35

It was a complex experiment arranged in split plot design with irrigations as main plots and varieties as sub plots. The treatments were all combinations of the following:—

Varieties		Irrigations	
V_1—Co. 312	I_1	Pre-monsoon 7 days	Post-monsoon 15 days
V_2—Co. L. 9	I_2	Pre-monsoon 7 days	Post-monsoon 30 days
V_3—Co. L. 29	I_3	-do- 14 days	-do- 15 days
V_4—Co. 453	I_4	-do- 14 days	-do- 30 days
V_5—Co. 617	I_5	-do- 21 days	-do- 15 days
V_6—Co. K. 30	I_6	-do- 21 days	-do- 30 days

Experiments were sown in the 2nd half of March, representing the normal planting time in the tract. The cane was sown in rows two feet apart at a seed rate of 40,000 two-budded setts per acre. Farmyard Manure before planting and Ammonium Sulphate with subsequent irrigations were applied at 100 lbs. Nitrogen per acre. The net plot size was 1/80th acre (10' ×54·5'). The Meteorological data for the year 1952-53 have been presented in Table II.

TABLE II

Meteorological data—Jullundur

Months	1952–53 Maximum Temperature (OF) Highest 1	Maximum Temperature (OF) Lowest 2	Maximum Temperature (OF) Mean 3	Minimum Temperature (OF) Highest 4	Minimum Temperature (OF) Lowest 5	Minimum Temperature (OF) Mean 6	Mean difference between 3 and 6	Average humidity Percentage	Rain-fall in inches	No. of rainy days
March ..	88·5	63·3	80·1	66·5	44·8	53·4	26·7	61	1·54	7
April ..	107·0	83·5	98·5	79·0	54·8	65·3	33·2	42	T	..
May ..	114·5	92·0	103·9	89·0	66·8	73·5	30·4	30	0·55	3
June ..	111·0	82·8	101·3	89·6	66·0	78·8	22·5	48	3·06	6
July ..	103·4	85·9	95·0	84·0	71·2	77·5	17·5	70	4·65	9
August ..	98·0	76·1	92·9	81·9	71·4	70·5	16·4	78	21·56	17
September ..	100·2	94·2	97·2	80·0	68·0	73·0	24·2	56	0·00	..
October ..	99·6	88·6	93·0	68·5	48·4	58·3	34·7	50	0·00	..
November ..	90·0	76·0	82·8	52·3	38·4	45·6	37·2	51	0·00	..
December ..	78·8	63·0	71·7	49·8	33·2	39·3	32·4	62	0·06	1
January ..	72·2	56·2	65·1	51·9	36·0	41·8	23·3	73	2·54	5
February ..	87·3	61·9	75·5	56·5	36·4	47·2	28·3	64	0·26	3
Total ..									34·22	51

The number of irrigations and acre-inches of water applied in 1952-53 were as given in Table III.

TABLE III

Irrigational intervals	Number of irrigations: Pre-monsoon	Post-monsoon	Total	Acre inches of water: By irrigations at 3″ each	Rain	Total
I_1	13	8	21	63·0	32·42	95·42
I_2	13	5	18	54·0	32·42	86·42
I_3	7	8	15	45·0	32·42	77·42
I_4	7	5	12	36·0	32·42	68·42
I_5	5	8	13	39·0	32·42	71·42
I_6	5	5	10	30·0	32·42	62·42

Main shoots were used for linear growth measurement and the same were used for studies on the other bionomics of the plants discussed in this paper.

EXPERIMENTATION

Tiller production

TABLE IV

Tiller formation per clump

Irrigational intervals	1952–53						
	Co. 312	Co. L. 9	Co. L. 29	Co. 453	Co. 617	Co. K. 30	Mean for I'S.
1	2	3	4	5	6	7	8
			Pre-monsoon				
7 days	3·9	4·5	4·3	3·2	3·0	3·7	3·8
14 days	5·0	4·1	4·7	2·9	5·5	3·9	4·3
21 days	3·9	3·6	4·0	3·0	2·5	3·2	3·4
Av. for V's.	4·3	4·1	4·3	3·0	3·6	3·6	
			Monsoon				
7 days	3·2	3·5	3·6	2·5	2·8	3·2	3·1
14 days	3·8	2·8	3·8	2·8	3·0	2·9	3·4
21 days	3·0	2·5	3·1	2·4	3·0	2·8	2·8
Av. for V's.	3·3	2·9	3·5	2·6	2·9	3·0	
Days Pre Post			*Post-Monsoon*				
7 15	2·2	2·8	2·7	1·7	2·3	2·3	2·3
7 30	2·9	2·7	3·2	2·2	3·0	3·0	2·8
14 15	1·9	3·3	2·2	2·6	1·8	2·3	2·2
14 30	1·8	2·1	2·9	1·8	2·2	1·8	2·1
21 15	2·7	2·3	3·6	3·0	2·3	2·6	2·7
21 30	2·6	2·6	2·7	2·9	2·9	2·5	2·7
Av. for V's.	2·4	2·5	2·9	2·2	2·4	2·4	

TABLE V

1952-53

Irrigational Treatments	Linear growth per main shoot in inches						
	Co. 312	Co. L. 9	Co. L. 29	Co. 453	Co. 617	Co. K. 30	Mean
			Pre-Monsoon (1st week of July)				
7 days	23·8	18·2	18·7	27·4	23·0	23·9	22·5
14 days	23·5	18·0	18·2	24·0	19·0	21·9	20·8
21 days	18·8	13·6	14·9	20·1	18·8	18·8	16·9
Av. for V's.	22·0	16·6	17·3	23·8	19·2	21·5	

TABLE V—(*Contd.*)

1952-53—(*Contd.*)

Irrigational Treatments	Linear growth per main shot in inches						
	Co. 312	Co. L. 9	Co. L. 29	Co. 453	Co. 617	Co. K. 30	Mean
	Monsoon (Mid September)						
7 days	62·2	57·3	59·6	77·9	73·7	59·6	63·0
14 days	62·4	58·1	57·8	74·4	67·5	59·7	63·3
21 days	57·9	51·4	52·3	68·9	67·5	53·2	58·6
Av. for V's.	60·8	55·6	56·6	73·6	69·6	57·5	
Pre-days Post- days	*Post-Monsoon (End-December)*						
7 15	77·5	62·1	65·6	85·9	80·1	61·7	72·2
7 30	76·6	66·3	62·8	78·5	79·7	62·6	71·1
14 15	69·1	71·0	69·2	86·7	80·3	65·0	73·7
14 30	72·1	63·0	73·8	82·0	79·2	69·3	73·2
21 15	63·3	62·0	65·4	79·4	75·0	62·0	67·9
21 30	64·5	58·0	58·3	73·4	70·0	53·6	59·6
Av. for V's.	70·5	63·9	65·9	81·0	77·4	62·4	

Thickness and Internodes of Canes

TABLE VI

Bionomics at Harvest

Observations	Mean for varieties 1952–53						Mean for irrigations 1952–53					
	Co. 312	Co. L. 9	Co. L. 29	Co. 453	Co. 617	Co. K. 30	I_1 11	I_2 12	I_3 13	I_4 14	I_5 15	I_6 16
Average number of internodes per cane ..	10·9	9·8	9·4	10·1	10·0	9·1	10·2	9·7	10·0	10·0	9·4	10·6
Average maximum thickness in cms. (Girth)	2·12	2·09	1·93	2·54	2·09	1·98	2·16	2·11	2·18	2·14	2·06	2·09

Tiller production in pre-monsoon and monsoon periods and cane formation in the post monsoon period was greater in case of liberal and normal irrigational treatments particularly in case of the latter.

Out of the varieties particularly Co. L. 29 followed by Co. 312 gave the maximum tillers during the pre-monsoon period.

Plant growth was markedly influenced by differential irrigations during pre-monsoons and the growth differences were significantly in favour of 7 days and 14 days irrigational intervals. The better growth under these treatments continued to persist even during monsoon and post-monsoon periods but the crop under restricted irrigational treatments was most benefitted from the rains. The post-monsoon differential irrigations, however, did not show any beneficial effect on growth.

As in the case of other bionomics, higher irrigations especially during pre-monsoon period have resulted in greater thickness and higher number of internodes of canes at harvest.

TABLE VII

Yield of millable canes

Irrigational intervals	Average yield of stripped canes in mds. per acre 1952–53						
	Co. 312	Co. L. 9	Co. L. 29	Co. 453	Co. 617	Co. K. 30	Mean for I's
Pre-days Post-days							
I'1/7 15	629	329	403	740	553	475	521·5
I'2/7 30	616	425	619	734	612	502	584·7
I'3/14 15	564	365	385	548	465	387	452·3
I'4/14 30	504	364	430	604	517	431	475·0
I'5/21 15	559	333	432	611	457	438	471·7
I'6/21 30	472	243	345	514	401	361	389·3
Mean for V's.	557·3	343·2	435·7	625·2	500·8	432·3	

Conclusions at 5 per cent. C.D. at 5% in mds. per acre

i. Irrigations	I'2	I'1	I'4	I'5	I'3	I'6	
	(584·6)	(520·5)	(475·0)	(471·8)	(452·3)	(388·3)	64·76
ii. Varieties	V_4	V_1	V_5	V_3	V_6	V_2	
	625·2	557·3	500·8	435·7	432·3	343·2	
iii. Interaction	Non significant.						102·24

While the higher number of irrigations influenced the yield favourably in almost all the varieties, their differential effect was less marked in the case of Co. 312, Co. L. 29 and Co. 19 varieties. These varieties, therefore, have a greater capacity to stand water shortage than the others. For rain-fed areas or where irrigational facilities are inadequate, cultivation of only such varieties can ensure successful cultivation of cane.

TABLE VIII

Juice analysis

Varieties	Sucrose Percentage on 21st/22nd January, 1952–53						
	Post-monsoon 15 days			Post-monsoon 30 days			Mean for V's.
	I'1	I'3	I'5	I'2	I'4	I'6	
Co. 312	13·83	14·22	13·54	13·60	13·45	14·11	13·79
Co. L. 9	12·58	13·95	14·14	12·86	14·12	13·87	13·59
Co. L. 29	12·90	16·72	16·19	15·37	16·80	16·80	16·30
Co. 453	13·79	14·34	14·06	12·35	14·18	14·00	13·79
Co. 617	14·19	15·10	14·29	13·54	14·21	14·11	14·24
Co. K. 30	13·50	14·16	14·38	12·77	13·17	12·24	13·25
Mean for I's	13·96	14·75	14·26	13·41	14·32	14·25	

Analyses were carried out at monthly intervals from November to February and the results for the month of January are presented. There are no significant differences in the quality of juice from different treatments. Less formation of sucrose under higher number of irrigations is due to better growth put in by the crop especially the late varieties. Such differences in the case of Co. L. 29, on early maturing variety were rather narrow, showing that due to its comparative low growth potential, the growth differences under different irrigational treatments were not wide. Restricted irrigations in the post monsoon period, however, tended to hasten maturity.

TABLE IX

Leaf Production

Irrigational Treatments	Leaf area per main shoot in square inches 1952–53						
	Co. 312	Co. L. 9	Co. L. 29	Co. 453	Co. 617	Co. K. 30	Mean for I's.
	Pre-monsoon (1st week of July)						
7 days	141·7	125·4	121·3	265·5	223·1	139·5	169·4
14 days	140·30	132·9	134·4	227·6	220·1	132·6	164·6
21 days	114·1	73·5	100·8	181·6	112·3	81·21	110·1
Av. for V's.	132·0	110·6	118·8	224·9	185·2	117·8	
	Monsoon (Mid-September)						
7 days	284·0	270·8	258·9	387·1	412·5	207·1	300·1
14 days	282·3	270·4	269·5	347·3	410·3	206·6	296·9
21 days	253·8	227·1	156·4	232·2	340·0	160·3	249·8
Av. for V's.	273·4	256·1	241·6	345·5	387·3	191·3	
Days (Pre, Post)	*Post-monsoon (End-December)*						
7 15	139·4	192·4	152·9	262·6	312·3	134·1	199·3
7 30	145·3	168·8	130·3	268·1	288·2	133·5	180·8
14 15	175·1	249·6	110·4	348·1	313·1	115·5	218·7
14 30	184·1	151·8	113·9	352·8	313·4	124·4	124·2
21 15	149·9	153·39	151·1	314·0	328·7	116·3	202·5
21 30	138·4	179·9	114·6	270·8	264·6	112·3	181·8
Av. for V's.	155·4	182·7	129·9	302·9	295·1	124·7	

Higher number of irrigations exhibited beneficial effect on the number and leaf area per stalk in almost all the varieties. Variations in these characters under liberal and restricted irrigations were, however, less marked in the case of Co. 312, Co. L. 9, Co. L. 29 which also showed comparatively less variation in yield. Varieties which are capable of standing water shortage, have also a capacity to produce more number of leaves even under unfavourable conditions.

TABLE X

Anatomical Studies

1952-53

Varieties	Av. moisture percentage last opened leaf	Av. No. of stomata per sq. mm.		Av. length per stomata in μ	Av. breadth per stomata in μ	Ratio of length to breadth	Av. cuticle deposition in μ
		upper surface	lower surface				
Co. 312	67·6	75·2	179·7	46·20	22·54	1:2·05	4·0
Co. L. 9	68·4	111·1	203·1	18·52	18·82	1:2·19	3·6
Co. L. 29	63·6	96·1	156·7	45·32	22·00	1:2·06	4·9
Co. 453	68·5	96·1	194·3	44·48	20·48	1:2·17	3·64
Co. 617	68·4	92·7	183·9	44·40	21·60	1:2·06	3·63
Co. K. 30	68·1	110·6	215·2	43·60	20·00	1:2·18	3·87

Both the number and size of stomata on the upper and lower surfaces of the leaf were less in the case of Co. 312, Co. L. 29 and Co. L. 9 varieties. The cuticle deposition, however, was higher on the same varieties as compared to others like Co. 453 and Co. 617. As the former varieties showed less yield variation under liberal and restricted irrigations, these varieties possess greater capacity to stand drought as compared to the other varieties. The less number of stomata, higher cuticle formation are thus indicative of the drought resistance in these varieties.

Discussion

Higher irrigations have been found to increase foliage, number and thickness of internodes and length of stalks in almost all varieties. Harbans Singh *et al.* (1951) found high positive correlation between these characters and final tonnage of canes as also amongst these different bionomics. The higher yield under increased irrigations is thus the resultant of improvement brought about in these canes and leaf characters. Out of the different varieties, Co. 312, Co. L. 29 and Co. L. 9 showed less yield variation under varying irrigational levels, whereas the performance of Co. 453 and Co. 617 was found to have been adversely affected under restricted irrigations. The anatomical studies have shown less number and small sized stomata and more of cuticle deposition in the case of Co. 312 and Co. L. 29 varieties. These characters according to Mameli-Calvino (1926) and Rao (1950) were found to be associated with drought resistance in Sugarcane. Co. 312 and Co. L. 29 possess higher capacity to stand drought and the same is reflected in their yields under liberal and restricted irrigations.

Summary

1. These experiments were carried out at Sugarcane Research Station, Jullundur with a view to assess the irrigational requirements of the important Punjab canes and the role played by some of the morphological, anatomical and physiological characters on their capacity to stand drought.

2. Of the different important treatments, liberal irrigations in the pre-monsoon period tended to increase the tiller production.

3. The varieties Co. L. 29, Co. 312 and Co. L. 9 showed higher tiller capacity and Co. 453 had the least production.

4. Growth in terms of stalk length of all varieties indicated a marked influence of higher irrigations in the pre-monsoon period. These differences though greatly narrowed down during Monsoons, continued to persist even at the time of harvest.

5. Crop under liberal irrigations put in higher per cent growth in the pre-monsoon period and comparatively less in the monsoon period than the growth recorded under restricted irrigation. The post-monsoon irrigational intervals did not reveal any appreciable effects on the linear growth of the varieties.

6. Under varying levels of irrigation during pre-monsoon period, the varieties Co. 312, Co. L. 9, Co. L. 29 showed less variation in growth as compared to Co. 453 and Co. 617, having been affected more adversely by restricted irrigations. All varieties made less growth under restricted irrigations.

7. Higher level of irrigations induced larger number of longer and broader leaves resulting in greater leaf area in pre and monsoon periods as compared to the restricted waterings. The varieties Co. 453 and Co. 617 showed greater variations in their leaf area under liberal and restricted irrigations in comparison to Co. 312, Co. L. 9 and Co. L. 29 indicating higher water requirements of the former varieties.

8. Higher number of irrigations also induced more of internodes, thickness and linear growth in all the varieties. Co. 312 produced the highest number of the internodes while Co. 453 the longest millable canes.

9. Highest yield of millable canes was recorded under liberal irrigations during pre-monsoon period, the variations in post-monsoon irrigations showed no such influence on this character.

10. Higher frequency of irrigations did not materially affect the juice quality though it depressed sucrose formation in early part of the ripening phase. Co. L. 29 an early variety behaved almost alike under different irrigational levels.

11. The varieties like Co. 312, found comparatively more resistant to drought, showed smaller sized and less number of stomata on the upper and lower surfaces of their leaves. The resistant varieties also exhibited greater thickness of cuticle in their foliage.

Acknowledgment

Authors are grateful to the Punjab Government and the Indian Central Sugarcane Committee for jointly financing the Sugarcane Research Scheme under which this work was undertaken. Authors' special thanks are also due to Sarvashri H. S. Saini and Pal Singh for helping in the investigation.

REFERENCES

Annual Reports of the Sugarcane Research Station, Lyallpur (1934-39).

——— Jullundur (1945-46).

——— Bihar, Pusa (1936-37 to 1939-40).

Annual Reports of Sugarcane Research work conducted at Shahjahanpur, Muzaffarnagar, Gorakhpur, Neloi (Estate) etc., in U.P. during 1953-54 Expt, 29.

Khanna, K. L. and Raheja, P. C. (1938). Water requirements of Sugarcane varieties during hot weather. *Proc. 20th Ind. Sci. Cong.*

Martin, J. H. (1920). The Comparative drought resistance of sorghum and Corn. *Jour. Amer. Soc. Agron.*, **22**: 986-93.

Mameli-Calvino, E. (1926). Zerophytic Characters of Sugarcane. NUOVO. *Gior. Bot. Ital*, **33**: 5-19, 1926 (*Biology Abstr.*, **2**: 18884, 1928).

Rao, J. Thulja Ram (1950). Zerophytic adaptations in Sugarcane for resistance to drought (*Int. Soci. Sug. Tech. 7th Cong.* Brisliane).

Singh, Harbans, Singh, Hardial and Singh, M. M. (1951). Irrigational and Manurial requirements of certain sugarcane varieties in the Punjab. *Proc. 1st Bien. Conf. Sug.cane Res. & Dev. Workers*, 1951, Coimbatore.

Research Notes

Albino Disease

THE investigations on Albino disease already conducted so far have yielded the following important information:—

1. Seed material plays an important role in the carry over of the disease. Shoots arising from the affected setts obtained from the affected canes invariably show symptoms of the disease.

2. Hot water treatment is helpful in mitigating the incidence of the disease but this method is not practicable on a large scale. It can be useful only in treating unclear seed material.

3. The varieties show variations in their susceptibility. The important ones with appreciable incidence of this disease are Cos. 245, Cos. 321, Cos. 514, Cos. 515 and B.O. 10.

Experiments on mineral spray of foliage of the affected crops are in progress. The chemicals used are Manganese. Magnesium, Iron, Copper and Zinc. The nature of the disease is yet to be established since attempts to reproduce it artificially have not been successful so far.

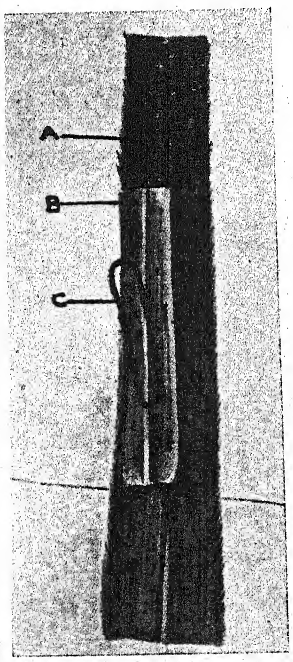
The position of the incidence of this disease in U.P. is being kept under constant and close watch.

(Director Sugarcane Research Shahjahanpur., U.P.)

An Easy Method for Carrying out Rust Inoculation

WHILE conducting rust inoculation on two months old seedlings of sugarcane the following method was adopted successfully. Heavily infected leaf material with fresh uredo sori were made into bits of convenient lengths dipped in water to moisten the surface and the sori were opened with a fine needle, thus exposing the uredospores. These bits were fixed as shown in the figure to the under surface of the leaf of the host at the required place by means of gemclips without causing any damage to the tissue of the host

Infected material fixed on to the host.



A. Host. B. Infected leaf bit. C. Gem clip.

leaf. The host leaves were moistened before the infected bits were placed. This moisture helps the germination of the uredospores. The inoculated plants were covered with alkathene bags for 48 hours and the

plants were sprayed with water twice a day. The infected bits were removed on the third day. By adopting this method successful infection was obtained in some of the varieties. This method was found to be advantageous over the other methods. (N. JALLEEL AHMED, Central Sugarcane Research Station, Cuddalore, Madras).

A NOTE ON THE BACTERIAL RED STRIPE DISEASE (*XANTHOMONAS RUBRILINEANS*) IN BOMBAY STATE

THE bacterial red stripe disease was first encountered in Bombay State on sugarcane variety Co. 419 at the close of the monsoon in the year 1955. Examination of the samples revealed that the symptoms were similar to those described by Cottrell-Dormer (1); Wood (5); *Lee et al.* (3) (4); and Christopher and Edgerton (2).

The paper presents some salient features of the disease, the morphological, cultural and biochemical properties of the bacterium as well as the pathogenicity tests undertaken at the Central Sugarcane Research Station, Padegaon.

The disease is characterised by the red to maroon coloured lines on sugarcane leaves. The stripes were found limited to the lamina and did not occur on the sheath or the shoot. The symptoms occur more intensely in fields that are thickly planted and heavily manured.

The bacterium causing red stripe disease was isolated from incised leaf tissue of Co. 419 on many occasions. Morphologically, the bacterium appears as small gram-negative rod, motile with polar flagella. It remains uncapsulated in glucose broth. Biochemically, the bacterium produced acid but no gas in mannite, glucose, lactose and sucrose. Starch was not hydrolysed but instead, the bacterium produced alkalinity in starch and maltose. Gelatine was liquified. Hydrogen sulphide was not produced from peptone water; indol was not formed from tryptophane in 14 days nor was nitrate reduced to nitrite.

On comparative reference to the biochemical activities, the bacterium isolated by us, resembles closely the one described by *Lee et al.* (3) (4) in Hawaii than the one isolated from the same disease by Christopher and Edgerton (2). However, the symptomatology and the cultural behaviour of the different isolates are more or less identical. Since the few differences in biochemical properties may not be very significant, the nomenclature of the bacterium isolated from the red stripe lesion at Padegaon has been retained as *Xanthomonas rubrilineans* (Lee).

The pathogenicity of the bacterial isolate was confirmed by numerous leaf inoculations made by covering the surface of the tender leaf with young bacterial culture from potato-dextrose agar medium and then scratching the inoculum into the leaf tissue with a sharp, sterile needle. The promising sugarcane varieties like Co. Nos: 475, 649, 658, 678, 683, 685, 718, 740, 744, 745, 759, 768, 771, 775, 787, 792, 794, 798, 799, 800, 818, 911, 915, and ORB—six were subjected to the "scratch test" and as a consequence, the following varieties viz., Co. Nos: 419, 658, 678, 718, 745, 775, 787, 792, 799, 800 and 911 exhibited the typical symptoms. Field observations at Padegaon have corroborated that the "scratch test" could, under suitable conditions, be used with advantage in arriving at the susceptibility of a sugarcane variety to the red stripe disease. (M. J. ALBUQUERQUE, Central Sugarcane Research Station, Padegaon, Bombay).

REFERENCES

Cottrell-Dormer, W. (1926). Queensland *Agri. Jour.*, **2** (25): 406-14.
Christopher, W. N. and Edgerton, C. W. (1930). *Jour. Agri. Res.*, **41** (3): 259-67.
Lee, H. A. and Jenings, W. C. (1924). Hawaii *Sug. Plant. Assoc. Expt. Sta.*, Circular 424.
Lu, H. S., Martin, J. P., Purdy, H. A., Barnum, C. C., Jennings, W. C. and Wheeler, D. M. (1925). Hawaii *Sug. Plant Assoc. Expt. Sta. Dept. Path.*, 99.
Wood, E. J. (1927). Top rot of sugarcane. Queensland *Agri. Jour.*, **28**: 208-81.

CHLOROSIS DISEASE OF SUGARCANE IN BIHAR

DURING recent years occurrence of chlorosis in sugarcane plants has been observed more frequently. In Bihar, it appears to be fairly wide spread though its incidence has been found to be low (as shown in the Table), the varieties affected being ten in number.

Symptoms: Leaves of the affected plants become pale yellow or yellowish white in colour and are devoid of chlorophyll. The canes may be affected either singly or the whole stool may be involved. The affected stalks become comparatively thinner and stunted in growth, with the result there is reduction in yield and deterioration in juice quality. Apparently the disease is similar to those reported from Uttar Pradesh (1) and Orissa (2) but differs in detail and appears to originate from different causes. Detailed observations made at Motihari in December, 1957 revealed the presence of three different types of chlorosis.

Incidence of Chlorosis Disease in Bihar during 1956-57

District	Factory area	Date of observation	Variety	Area surveyed in acres	Area affected in acres	Incidence
Saran	Siwan	19-6-56	Co. 313	10·7	0·7	Rare
	Marhowrah	19-9-56	,,	128·1	22·8	,, to stray
	Sasamusa	19-4-56	B.O. 11	32·2	0·6	,,
	Sidhwalia	8-5-57	Co. 513	91·8	2·2	,,
	Harkhua	11-5-57	B.O. 3	88·5	0·6	,, to stray
		,,	B.O. 11	75·0	0·8	,,
Darbhanga	Ryam	26-4-56	Co. 453	0·9	0·2	,,
		19-4-57	B.O. 11	9·7	0·3	,,
		,,	Co. 513	107·0	0·5	,,
	Hassanpur	24-4-56	Co. 513	8·8	0·8	,,
		,,	B.O. 17	0·8	0·9	,,
	Lohat	15-4-57	B.O. 11	71·5	2·5	,,
		,,	Co. 513	35·9	0·4	,,
Champaran	Lauriya	14-6-56	B.O. 3	95·1	1·0	,,
		,,	Co. 419	38·5	12·0	,,
		26-4-57	B.O. 14	26·4	2·0	,,
		,,	B.O. 17	12·7	0·7	,,
	Majhaulia	12-6-56	,,	35·9	5·3	,,
		,,	B.O. 21	4·1	0·3	,,
		,,	B.O. 29	1·0	0·5	,,
	Bagaha	27-4-56	B.O. 14	118·8	2·5	,,
		,,	Co. 513	31·0	1·4	,,
	Chakia	24-4-5	B.O. 11	51·0	0·6	,,
Gaya	Warisaliganj	4-5-56	Co. 419	46·0	0·3	,,
			Total ..	1,134·6	60·7	

1. Uniform loss of chlorophyll in leaves with no sprouting of buds. This was found to be due to the poor root development.

2. Chlorosis with sprouting of buds at the top and below forming small aerial shoots, usually associated with top and stem borers.

3. Discoloration of crown leaves in strips or sheath; sprouting of buds common forming bunch of chlorotic leaves much reduced in size.

Attempts to isolate the causal organism, if any, have so far failed. It appears that the disease is of virus origin but the conclusion is only tentative. (S. L. Sharma, R. K. Singh and B. B. Shrivastava, Sugarcane Research Institute, Pusa, Bihar).

REFERENCES

New Chlorotic disease. 1957. *Ind. J. Sug. Cane Res. & Dev.*, **1**: 103-04,
Ramachander, G. (1957). A case of near albinism in cane. *Ibid.*, **1**: 171.

Miscellany

Seminars of the Scientific Staff of the Sugarcane Breeding Institute, Coimbatore

THE first Seminar of the scientific staff of the Sugarcane Breeding Institute, Coimbatore, met on 12-5-1958. Shri K. V. Srinivasan, Mycologist at the Institute, spoke on "*Certain recent studies on the microflora of the rhizosphere of sugarcane*". Defining 'the rhizosphere' as that portion of the soil which is subject to the influence of the roots of the concerned plant, he described the characteristic features of the rhizospheres of the different species of *Saccharum* and some of the hybrid varieties studied by him. In general *S. officinarum* harboured higher numbers of bacteria and fungi, while in *S. Barberi* and *S. spontaneum*, their population was low. Certain varieties had more numbers of *Pythium*, *Helminthosporium*, *Rhizoctenia*, etc. while others had lower numbers of these genera. It was noticed that the bacteria in rhizosphere had a large proportion of amino-acid and vitamin requiring forms as compared to those in the soil away from the roots. The rhizospheres of seedling populations derived from different crosses showed different patterns of flora. Some progenies supported a large number of pathogenic organisms especially *Pythium gramanicolum* and this was correlated with greater susceptibility to seedling root-rot. *Pythium* root rot and chlorosis complex of sugarcane were investigated. The study of the rhizosphere of chlorotic plants had shown that nematodes are concerned in the building up of pathogenic population of *Pythium* and they interfere with the absorption of iron by the plants and thereby cause chlorosis. The availability of trace elements in the rhizosphere and its implication on microbial populations was pointed out.

2. At the Second Seminar, Shri R. R. Panje, then Botanist at the Institute, gave a talk on "*The distribution of chromosome numbers of the variants of S. spontaneum*". He presented the indications obtained as a result of an extensive survey of the distribution of the haploid chromosome numbers of nearly 400 variants of spontaneums assembled at Coimbatore. Regarding geographical distribution trends, the forms with smaller numbers n=20 to 40 are predominant in the central region comprising India, N. W. Frontier Province and Turkestan. In this central region, the sub-Himalayan area can be considered to be a place of high evolutionary activity as it shows both the lowest chromosome number and also a large variation in the distribution of forms such as n=20, 24, 26, 27, 28, 30, 32 and 40. South East Asia, China and Malaysia are characterised by forms having high chromosome numbers, which is also the case with variants from Africa and Mediterranean.

The occurrence of forms with the lowest chromosome number n=20, one at north western U.P. a form at Nepal and four from West Bengal and Orissa indicates that the home of these forms is somewhere in the sub-montane area of the Himalayas. The n=32 forms, which predominate in the sub-continent, are also likely to have arisen in the area between Nepal and North Western U.P. but have migrated to the south and made the peninsula their home. Probably the concentration of forms in certain sectors may have been caused by the prevailing ecological conditions. The n=40 forms, for example, seem to prefer hilly areas with heavy rainfall, some are found in the Western ghats and others in the Assam and Nepal areas. In the Nepal area side by side with n=40 form, a n=20 type also occurs, giving evidence of their close inter-relationship.

The chromosome numbers met with in the eastern sector from Burma eastwards range from n=32 to n=56 with one or two exceptions with high numbers, and probably they are hybrids. Singapore forms having n=32 resemble the Indian variants and could have been transported by human agencies. Again the occurrence of n=56 in parts of China is to be accounted to the commercial intercourse between China and Indonesia. Coming to the western region comprising African and Mediterranean countries, the speaker referred to the presence there of polyploid forms with n=56 and n=64 together with some aneuploids and also the absence of n=48 types in Africa which is interesting.

3. At the third Seminar Shri R. A. Agarwal, Entomologist at the Institute, presented a paper on "*Insect resistance in crops with special reference to Sugarcane*". He referred to the various types of plant characters responsible for insect resistance in crop plants such as physical hardness of plant parts which makes puncturing difficult; chemical as the presence of some unpalatable substance in the sap or physiological such as period of maturity causing a time break in the incidence of susceptible plant stage and insect development. He then reviewed the incidence of pests in sugarcane pointing out that the time of attack and extent of damage by the pests varied in the different cane tracts of the country. Thus it may not be possible evolve a single variety which is capable of proving resistant to all pests and which could suit all growing conditions. However on the basis of individual characters possessed by some varieties, it has been possible to isolate some of the causes responsible for resistance or susceptibility against ceratin pests.

In the case of sugarcane, the following associations between plant features and resistance to various pests have been reported by different workers: The hardness and length of leaf spindle, the hardness of the leaf mid rib and the occurrence of large number of bristles on the lower side of the mid rib are factors concerned with resistance against top borer damage; early vigour coupled with vigorous shoot growth confers resistance to early shoot borer; a solid cane with a hard rind composed of heavily lignified tissues confers resistance to internodal borers. A variety with tough and narrow leaves offers resistance to Pyrilla attack; mite damage is resisted through the absence of grooves between the veins on the lower surface of leaf blades and types which are self trashing and having a low number of stomata per unit area of the rind are resistant to damage by scale insects.

The speaker towards the end referred to the possibility of evolving insect resistant types through breeding and progeny studies.

4. '*Stem epidermis of Saccharum spontaneum*' was the subject presented at the 4th Seminar by Shri C. N. Babu, Assistant Sugarcane Expert. After referring to the general nature of the stem epidermis in grasses, he described the pattern in *Saccharum* with its typical long and short cells, their component structures and associations. In a survey of the epidermal patterns studied individually in about 400 variants of *Saccharum spontaneum*, it was found that the percentage of cork-silica cells pairs to the total number of short cell locations in the stem epidermis showed a relationship to the chromosome numbers of the variants. In the low chromosome forms the above percentage was generally high while in higher polyploids, it was low. It was, however, pointed out that the lowest chromosome group ($n=20$) was exceptional in having nil or very small percentage of silicosuberous couples and in this respect they resembled the higher polyploids. The variants in the $n=40$ group showed many intermediate types and gradations in the pattern. About 35 per cent of the forms had the silicosuberous couple pattern and another 35 per cent the solitary cell pattern while the rest were more or less equally distributed between the intermediary patterns. The speaker felt that the $n=40$ stage marked the transition stage in the development of the different stem epidermal patterns observed in *S. spontaneum*. (DIRECTOR, Sugarcane Breeding Institute, Coimbatore, Madras).

BOOK REVIEW

THE Indian Sugar Industry (1957-58 Annual). Editor M. P. Gandhi; Published by M. P. Gandhi & Co. Jan Mansion, Sir Pherozshah Mehta Road, Fort, Bombay-1, pp. 350; Price Rs. 6·00; V.P.P. Rs. 7·00.

The latest edition of Shri Gandhi's " Indian Sugar Industry Annual, as usual provides a good deal of up-to-date factual information pertaining to Sugar and Sugarcane Industries in the country. The data have been made more comprehensive and the latest figures pertaining to the year 1957-58 have been included. The statistical section contains authentic figures relating to practically every aspect of this important industry viz. cane production, cane yields per capita consumption in some of the important countries of the world, *gur* and *khandsari* production, taxes on sugar and sugarcane. It also includes useful information about the capacities of factories; acreage under Sugarcane; value of sugar exports from India, world sugar crop figures; etc. Other sections of this publication include varied information on legislation relating to sugar industry. The Sugar Export Promotion Act 1958 has been reproduced for ready reference.

Important subjects like sugarcane production, by-products of sugar industry, sugar exports and sugar consumption have been reduced in detail and the world sugar situation has also been surveyed. This is a comprehensive type of publication which would prove useful to all interested in the different aspects of sugar and sugarcane industries—V.P.S.

Publications on Tobacco

Periodicals:

	Single copy	Annual Subscription
"INDIAN TOBACCO" - English Quarterly	**nP. 75**	**Rs. 3**
"TOBACCO BULLETIN" - English (Statistical) Quarterly	**nP. 50**	**Rs. 2**
"TAMBAKU" - Hindi Quarterly	**nP. 38**	**Rs. 1·50**
"POGAKU" - Telugu Quarterly	**nP. 38**	**Rs. 1·50**
"TAMAKU" - Gujarati Quarterly*	**nP. 38**	**Rs. 1·50**

Advertisements are accepted for publication in all the above-mentioned periodicals.

TOBACCO DIRECTORY containing names and addresses of whole-sale dealers, commission agents, grower-curers, warehouse-keepers, manufacturers and exporters handling 2000 mds. or more of different varieties of Indian tobacco, prominent tobacco growers, tobacco growers' and traders' associations and co-operative societies, importers of Indian tobacco in different countries, Indian Government Trade Representatives abroad and Trade Representatives of Foreign Governments in India, is to be published shortly.

Advertisements are accepted. Advertisement tariff can be obtained on request.

Pre-publication price: Rs. 15 (Rs. 2/- postage extra)

INDIAN TOBACCO ATLAS contains 45 maps, historiograms and graphs showing centres of tobacco cultivation, research, marketing etc. and covering all aspects of Indian tobacco production, industry and trade including the trend in tobacco trade in major tobacco exporting and importing countries of the world.

Price Rs. 17·00 (Rs. 1·50 postage extra)

PROCEEDINGS OF THE FIRST CONFERENCE OF TOBACCO RESEARCH WORKERS IN INDIA.

Price Rs. 2·00.

Attractive terms are offered for advertisement agents, book sellers and news agents.

For copies and other particulars, please write to:—

The Secretary, Indian Central Tobacco Committee, No. 38, Mount Road, Madras—6

**Correspondence and remittances relating to the Gujarati Journal should be sent to:—*

The Director, Institute of Agriculture, Anand (W. Rly.)

SUGARCANE RESEARCH IN INDIA DURING 1929-54

The Ad-Hoc Expert Sub-Committee of the Indian Central Sugarcane Committee consisting of Sarvashri Lal Singh, N. L. Dutt and K. L. Khanna, after visiting a number of sugarcane research stations in operation in the States and looking through voluminous data collected under the sugarcane research and development schemes, have prepared the Resume of Sugarcane Research in India during 1929-54. It contains in the form of notes the recommendations that have emerged as a result of the research work done under Sugarcane Research Schemes both at the Central and States Institutes, on different aspects of sugarcane research based on the different aspects of sugarcane cultivation. These notes have been arranged accordingly as different chapters e.g., Sugarcane Agronomy, Sugarcane Physiology, Soil Studies etc.

The Resume presents not only an All-India picture but important details of studies carried out in the States are also included. The Resume under the title of 'Review on Sugarcane Research in India during 1929-54' appeared in a serial form in the Indian Journal of Sugarcane Research & Development and has now been compiled as a single book with graphic and illustrated cover in coloured design. The price per copy (exclusive of postage) is Rs. 5/-...... and is available from the Secretary, Indian Central Sugarcane Committee, 19-20, Rohtak Road, New Delhi-5.

ANNOUNCEMENT

Indian Council of Agricultural Research

THE RAFI AHMED KIDWAI MEMORIAL PRIZES FOR AGRICULTURAL RESEARCH

The Indian Council of Agricultural Research has, with a view to creating an incentive for research workers and to recognising outstanding research work done by them in the fields of agriculture, animal husbandry and allied subjects, instituted 11 prizes of the value of Rs. 5,000 each. These prizes are known as "The Rafi Ahmed Kidwai Memorial Prizes for Agricultural Research" and one prize will be awarded biennially i.e. once in two years for outstanding research work done in India in each of the following subjects:—

1. Agronomy,
2. Agricultural Engineering,
3. Agricultural Chemistry,
4. Agricultural Botany,
5. Agricultural Zoology (including Fisheries)
6. Horticulture,
7. Animal Breeding,
8. Animal Nutrition (including Physiology and Biochemistry),
9. Animal Diseases,
10. Dairying, and
11. Agricultural and Animal Husbandry Economics and Statistics.

2. These prizes will be in the form of gold medals or cash or both and one prize in each subject will be awarded on the basis of outstanding results of researches achieved by research workers in the country either individually or jointly, during the Calendar years 1958 and 1959, i.e., 1st January, 1958 to 31st December, 1959. Results achieved prior to the calendar year 1958 or after the calendar year 1959 will not be recognized for the purpose of the present award.

3. The award of each of the prizes shall be based on significant advances in human knowledge in a particular subject as revealed by books, monographs or papers published in the name of the candidate or any other unpublished account of the outstanding research work done or discoveries and inventions made by him. The selection of a candidate for the award of a prize will be made on the recommendations of a Judging Committee consisting of eminent scientists appointed for the purpose by the Indian Council of Agricultural Research. The award of a prize may be made to more than one research worker and the prize money divided amongst them in such proportion and manner as may be decided by the Council.

4. All research workers, engaged in research work in India, in the fields of agriculture, animal husbandry and allied sciences are eligible for competing for these prizes. Applications should be submitted in quadruplicate in the prescribed form, which can be had, free of cost, from the Secretary, Indian Council of Agricultural Research, Dr. Rajendra Prasad Road, New Delhi. Candidates working in Research Institutes etc., should submit their applications through the Head of the Institute/Department etc. Others may submit their applications direct.

5. All applications should be sent addressed to the Secretary, Indian Council of Agricultural Research, Dr. Rajendra Prasad Road, New Delhi, so as to reach him not later than the 30th June, 1960. The cover of applications should be superscribed as under:

> "Application for the award of The Rafi Ahmed Kidwai Memorial Prize for Research in.........
> ....

Applications received after the 30th June, 1960 will not be considered.

A COMPLETE HARVEST EXPERIMENT ON SUGARCANE FOR THE ESTIMATION OF YIELD BY SAMPLING

By

P. S. SREENIVASAN

(Agricultural Meteorology Division, Poona)

INTRODUCTION

"HARVEST by sampling" to estimate the yield of a crop, may be conveniently divided into two categories (a) from zones or districts growing the crop on extensive area and (b) from experimental fields wherein the crop is grown in plots according to statistical layout, such as randomised blocks. In the former case the sample may be quite large in size. For example, in Bombay State the ultimate unit of sampling used by Ranga Rao and Sharma (1957) in crop cutting experiment of sugarcane is 1/80th of an acre ($33' \times 16\frac{1}{2}'$) which are located at random, two in each village. In the latter case, where the plot size itself is only 1/20th of an acre, as in the case of sugarcane under crop-weather studies, the sample should be quite small in size. This latter aspect has received lot of attention from research workers on Agricultural Meteorology, at Poona, viz., Kalamkar *et al.* (1943), Mallik *et al.* (1945) and Sreenivasan (1942, 43, 50, 59) on the lines of work started by pioneer workers such as Clapham (1929, 1931a, b), Kalamkar (1932), Immer (1932) and Yates and Zacopanay (1935).

The need to harvest small experimental plots by sampling, when the entire field can be harvested with ease, is mainly two-fold, namely (a) to give conglomerate information on various crop attributes such as density, height, thickness, sucrose content etc. for the units harvested and (b) to indicate the amount of variability present within a plot. This paper deals with one such complete harvest experiment designed to give information on the optimum sample size and shape for the estimation of the yield of sugarcane, variety POJ 2878. This experiment was carried out at the Agricultural College farm, Poona, on the crop-weather experimental plots, with the kind co-operation of the staff of the Statistical Branch of the Division of Agricultural Meteorology.

MATERIAL AND METHOD

The complete harvesting experiment was carried out from 17-1-1952 to 20-1-1952 on POJ 2878 which was grown in six plots for crop-weather studies. Each plot was $48' \times 48'$ and this was divided into two equal sub-plots along the rows. The rows were four feet apart. Hence each sub-plot contained six rows, each 48 feet in length. Each row was harvested in units of two footlengths, yielding 24 units. Thus there were 1728 units in all, with 144 units in each sub-plot. Great care was exercised at the time of cutting to leave uniform stumps and tops. Canes were cut with sickles and were weighed immediately in the field itself on Avery balances. Although weighing was done correct to $\frac{1}{4}$ ounce, before analysis, these weights were expressed correct to two ounces and in whole numbers.

A few particulars regarding the crop are given below:

(1) The canes were planted in furrows on 14-1-1951.

(2) A set with three eye-buds was planted in every footlength of furrow.

(3) The crop was irrigated on 23 occasions.

(4) A basal dressing of 50 cartloads of farmyard manure and top dressing of 225 lbs. of nitrogen per acre in the form of groundnut cake and ammonium sulphate, were given.

(5) The crop was harvested on 17-1-1952.

(6) The yield of canes per acre for POJ 2878 was 38·3 tons

RESULTS

(a) *Frequency distribution of the yields:* In the first instance, the frequency distribution of yields for units of two footlengths and four footlengths were studied. Table I gives the frequency distribution of yield from 1728 units of two footlengths and two frequency distributions of yields from 864 units of four footlengths, viz., two contiguous two footlengths and two parallel two footlengths of rows. The mean, g_1 and g_2 and their errors are also given in the Table.

TABLE I

Frequency distributions of the Yield of Cane

Weight of cane (in 2 oz.)	Frequency of 2 foot-length units		Weight of cane (in 2 oz.)	Frequency of samples made up of two units of 2 foot lengths each			
				Contiguous units		Parallel units	
	Actual	Expected		Actual	Expected	Actual	Expected
0–19	14	21·4	60–79	1		2	6·0
20–39	21	18·4	80–99	3	6·1	4	
40–59	54	68·3	100–119	3		7	8·0
60–79	153	136·3	120–139	4	10·0	16	15·9
80–99	213	222·1	140–159	20	21·5	28	27·9
100–119	305	292·5	160–179	33	40·2	44	46·1
120–139	321	314·1	180–199	76	65·4	78	66·5
140–159	279	272·7	200–219	90	93·4	76	87·3
160–179	192	193·0	220–239	133	116·1	91	103·3
180–199	90	110·5	240–259	124	126·7	109	110·4
200–219	43	51·5	260–279	128	120·4	122	106·4
220–239	27	19·5	280–299	86	99·7	102	92·6
240–259	10		300–319	68	72·6	79	72·6
260–279	4	7·7	320–339	46	46·0	44	51·4
280–299	2		340–359	20	25·4	22	32·9
			360–379	17	12·3	21	19·0
			380–399	7		5	9·9
			400–419	2		8	
			420–439	3	7·9	2	7·7
			440–459	0		3	
			460–479	0		1	
Total number of samples	1,728	1,728·0	..	864	863·7	864	863·9

	2 foot-length units	Contiguous units	Parallel units
Mean yield of cane (in 2 oz.)	126·13	252·03	252·36
S.E. of mean ..	1·045	1·842	2·114
g_1 ..	0·181	0·161	0·079
S.E. of g_1 ..	0·0594	0·0833	0·0833
g_2 ..	0·308	0·290	0·215
S.E. of g_2 ..	0·1187	0·1662	0·1662
X^2 value ..	26·21	19·37	21·44
Significant value of X^2 at 5 per cent level ..	19·67	22·36	25·00

S. E. means standard error.

g_1 which is a measure of asymmetry and g_2 which is a measure of kurtosis are significant and positive for the sample of size two foot-lengths while the corresponding values for samples of size four foot-lengths are not significant. These conclusions are also confirmed by the x^2 values given in the table. Also the relative standard error is the least for samples of four foot-lengths made up of two contiguous two foot-length. The type of change taking place by combining two two-foot-lengths is brought out in figure 1 which gives histogram of distribution of the yield for these samples as well as the normal curve for yield for the units of two foot-lengths.

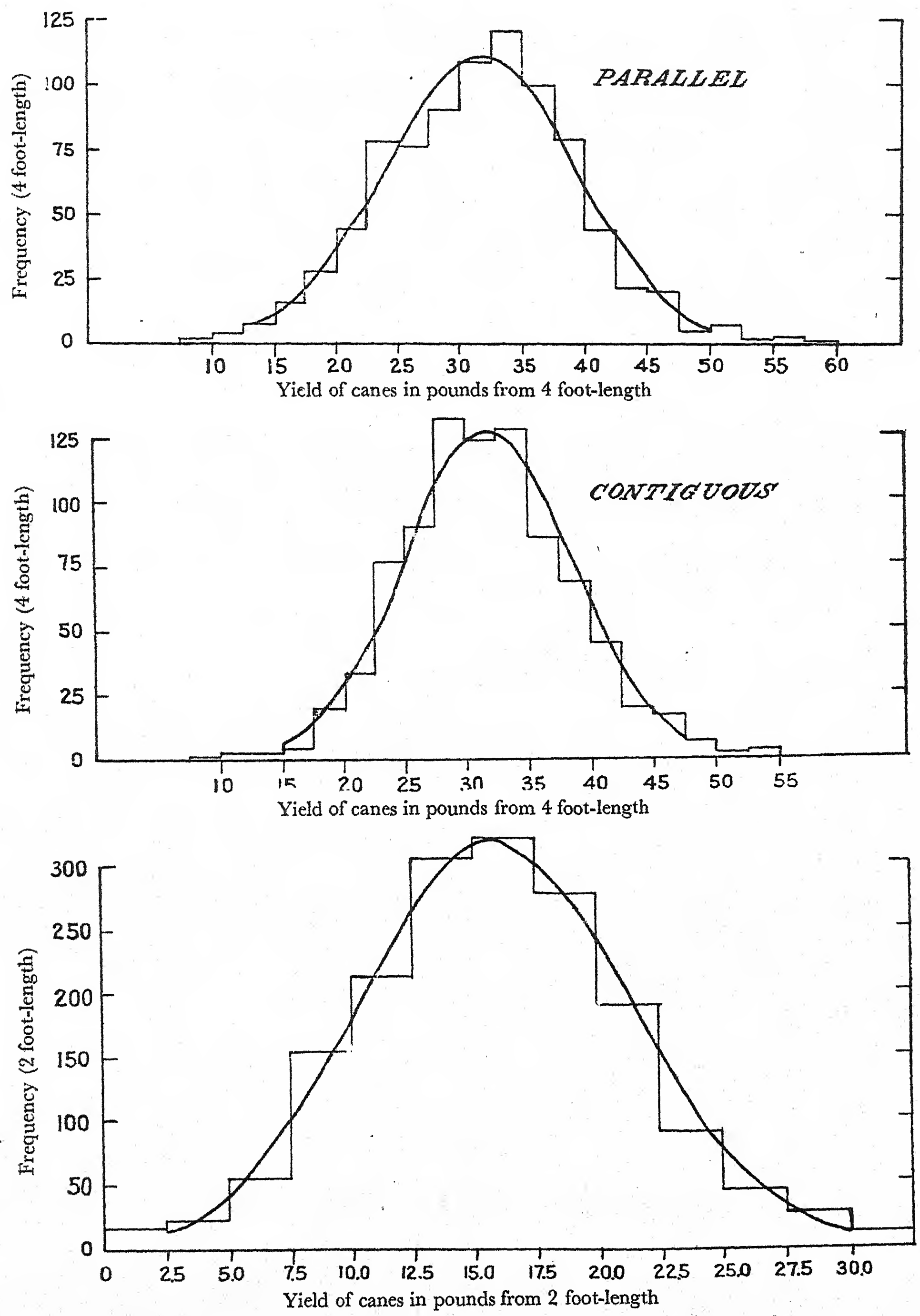


Fig. 1. Histogram of yield from 2 and 4 foot-length of row and their normal curves

(b) *Variance between sub-plots in relation to the orientation of rows:* In evolving a suitable sampling technique, as the aim is to minimise the standard error accruing from the samples at the cost of those from the sub-plot and within sample, the plots were divided to arrive at the most appropriate sub-plot size. Table II shows the variance due to plots, sub-plots and within sub-plot. When the plots were divided into two equal sub-plots along the row, with each sub-plot containing six rows of 48 ft. in length, the variance due to sub-plots was significant. However, when the plots were divided into two equal sub-plots across the rows, the variance between sub-plots was not significant. In order to see whether further stratification will remove appreciable amount of variation from within sub-plot variance, the sub-plots obtained by splitting the plot into two equal halves along the row, were in their turn divided into two equal halves, along as well as across the rows. The analysis of variance shows that the variances due to the two halves divided along the row is just significant at five per cent level of probability and hence may be advantageous to divide into smaller plots of size $12' \times 48'$ which means three rows of 48 ft. in length. Since three rows will restrict the spread of sampling units across the rows to three, further analysis with various sample sizes and shapes was carried out with sub-plots of dimension $24' \times 48'$ containing six rows of 48 feet in length.

(c) *Analysis of variance:* The units of two root lengths were grouped into samples of size 2, 3, 4, 6, 8, 12 and 24 units and of various shapes. Then, by the usual analysis of variance, the variations present between 12 sub-plots, between samples and within samples were found out.

TABLE II

Analysis of Variance for various sub-plot sizes and shapes

Source of variation	Degrees of freedom	Sum of squares	Mean square
(i) *Plots divided into two equal sub-plots along the row*			
Between plot	5	54,757	10,951†
Between sub-plot	6	34,745	5,791†
Within sub-plot	1,716	3,245,342	1,891
Total	1,727	3,334,844	1,931
(ii) *Plots divided into two equal sub-plots across the row*			
Between plot	5	54,757	10,951†
Between sub-plot	6	6,382	1,064
Within sub-plot	1,716	3,273,705	1,908
Total	1,727	3,334,844	1,931
(iii) *Sub-plot of* (i) *above into two equal halves along the row*			
Between the halves of the sub-plot	12	43,636	3,636*
Within the halves	1,704	3,201,706	1,879
Total@	1,716	3,245,342	1,891
(iv) *Sub-plots of* (i) *above divided into two equal halves across the row*			
Between the halves of the sub-plot	12	12,482	1,040
Within the halves	1,704	3,232,860	1,897
Total	1,716	3,245,342	1,891

*Significant at 5 per cent level. †significant at 1 per cent level.
@Total is same as within sub-plot given under (i) above.

For a sample size of eight foot length of row (i.e. four units of two foot length each) the allocation of the degrees of freedom in the analysis of variance will then be as follows.

Source of information	Degrees of freedom
Between sub-plot	11
Between samples	420
Within sample	1,296
Total	1,727

Only the combinations which can be developed without omitting any of the smallest units of two foot length of row were worked out in this study. These combinations are given in Table III along with suitable explanation regarding the arrangement of units in the sample.

TABLE III

Sizes and shapes of samples studied

Sl. No.	Size of the sample	Arrangement of units in the sample	Explanation
1	2	2v	Two parallel units of 2 foot-length each.
2	2	2h	Two contiguous 2 foot-lengths
3	3	3v	Three parallel units
4	3	3h	Three contiguous units
5	4	2h × 2v	Two parallel 4 foot-lengths
6	4	4h	Four contiguous units.
7	6	6v	Six parallel units
8	6	2h × 3v	Three parallel 4 foot-lengths
9	6	3h × 2v	Two parallel 6 foot-lengths
10	6	6h	Six contiguous units
11	8	4h × 2v	Two parallel 8 foot-lengths
12	8	8h	Eight contiguous units
13	12	2h × 6v	Six parallel 4 foot-lengths
14	12	4h × 3v	Three parallel 8 foot-lengths
15	12	6h × 2v	Two parallel 12 foot-lengths
16	12	12h	Twelve contiguous units
17	24	4h × 6v	Six parallel 8 foot-lengths
18	24	8h × 3v	Three parallel 16 foot-lengths
19	24	12h × 2v	Two parallel 24 foot-lengths
20	24	24h	Twenty-four contiguous units.

v-across the row.　　h-along the row.

(d) *Variance between samples in relation to the size of the sample and to the orientation of the rows:* Table IV gives the results of the analysis of variance together with the intra-class correlation present between the units within samples. Since all the 144 units in each sub-plot as well as all the 12 sub-plots have been utilized for all sample sizes and shapes, the variances due to sub-plots and the total variances remain constant being 8136·6 and 1931·0 respectively. The variances between samples decrease rapidly as the sample size increases from two foot length to eight foot length and thereafter they remain steady. Also, the variances are in general smaller when the samples stretch along the rows than when they are spread across the rows. The variances within samples remain more or less steady except when the sample is four foot-length of cane in the same row (sample serial number 2) where the variance is high.

The intra-class correlation corroborates this inference. The magnitudes of the intra-class correlation for any given sample size are not significantly different except when the sample is made up of two foot-length of crop in each row.

(e) *Efficient sizes and shapes of the sample:* Table V gives the standard errors from variances given in Table IV together with the standard error of the mean yield for each sample namely σ s /√n where n is the number of units of two foot-length. It is seen that the standard error of mean yield decreases rapidly as sample size increases from two foot lengths to eight foot lengths and thereafter gradually. This decrease in the standard error of the mean is brought out very vividly in figure 2 which gives this error for samples elongated along the rows and across the rows. It is also seen that samples elongated along the rows are more efficient than those spread across the rows. A sample size of eight foot-length in the same row appears to be highly efficient.

TABLE IV

Analysis of Variance for different sizes and shapes of samples

Sl. No.	Size and shape	Variance between samples	Variance within sample	Intra-class correlation
1	1h+2v	1843·0	1938·8	-0·025
2	2h+1v	1372·7	2402·5	-0·273†
3	1h×3v	1885·8	1893·9	-0·001
4	3h×1v	1288·9	2186·1	-0·160†
5	2h×2v	1380·3	2056·8	-0·090†
6	4h×1v	1274·4	2090·1	-0·108†
7	1h×6v	1819·7	1904·9	-0·008
8	2h×3v	1418·8	1981·8	-0·050†
9	3h×2v	1370·8	1991·0	-0·055†
10	6h×1v	1251·6	2013·8	-0·067†
11	4h×2v	1349·7	1964·3	-0·041†
12	8h×1v	1267·8	1975·3	-0·047†
13	2h×6v	1303·2	1940·2	-0·028†
14	4h×3v	1372·2	1934·5	-0·025†
15	6h×2v	1323·0	1938·6	-0·027†
16	12h×1v	1474·8	1925·9	-0·020*
17	4h×6v	1154·5	1917·9	-0·017†
18	8h×3v	1373·1	1910·0	-0·012*
19	12h×2v	1300·0	1912·6	-0·014*
20	24h×1v	1613·1	1910·3	-0·006

*Significance at 5 per cent level.
†Significance at 1 per cent level.

(f) *Estimation of yield by random sampling:* From a complete harvest experiment data it is possible to work out efficiency for various percentages of sampling by using the expression developed by Yates and Zacopanay (1935) namely,

$$\frac{1}{1+f(1-x)/x}$$

where f is equal to the error variance (variation between samples) expressed as a fraction of total error variance

TABLE V

Standard Errors from Variances in Table IV together with Standard Error of mean yield for each sample

Sl. No.	Size and shape	Between sample error	within sample error	$\sigma_s/\sqrt{n}$
1	1h×2v	42·93	44·03	30·36
2	2h×1v	37·05	49·02	26·20
3	1h×3v	43·43	43·52	25·07
4	3h×1v	35·90	46·76	20·73
5	2h×2v	37·15	45·35	18·58
6	4h×1v	35·70	45·73	17·85
7	1h×6v	42·66	43·65	17·42
8	2h×3v	37·67	44·51	15·38
9	3h×2v	36·02	44·62	14·71
10	6h×1v	35·38	44·88	14·44
11	4h×2v	36·74	44·32	12·99
12	8h×1v	35·61	44·44	12·59
13	2h×6v	36·10	44·05	10·42
14	4h×3v	37·04	43·98	10·69
15	6h×2v	36·37	44·03	10·45
16	12h×1v	38·40	43·88	11·09
17	4h×6v	33·98	43·79	6·94
18	8h×3v	37·06	43·70	7·56
19	12h×2v	36·06	43·73	7·36
20	24h×1v	40·16	43·60	8·20

and x is a fraction of the plot to be sampled. Also it is possible to select at random, the required number of units from each sub-plot and to calculate the percentage information from the formula developed by Yates and Zacopanay (1935), namely, P=100(1-L) where $L=\frac{n-2}{n}(1-\frac{k}{h})\frac{B}{A}$ where P=percentage information L=loss of information, $\frac{k}{h}$=proportion of sub-plot sampled, B=variance between samples, A=variance between sub-plots, n=degrees of freedom for sub-plots.

In figure 3, the theoretical percentage information curve and a free hand curve to the percentage information obtained by random sampling are indicated. It is observed that for percentages of sampling below 20, the percentage information obtained by random sampling is slightly more than the theoretical value. Table VI gives, in addition to the percentage information both actual and theoretical, the mean yield per four foot-length as estimated by random sampling method. On the whole, 8·3 per cent sampling yields good results. Hence 8·3 per cent sampling will mean selection of 12 units in each subplot. This amounts to selection at random of three samples of size eight foot-length of row, which was already arrived at in section 'e'. It may be mentioned here that these results justify in all respects the present sampling technique used in co-ordinated crop-weather study for sugarcane crop.

(g) *Random sampling with various sample sizes and shapes:* It has already been noticed from Tables IV and V that the efficiency of the sample increases as the sample size increases. For the optimum percentages of sampling namely 8·3 percentage a set of random samples for various sizes and shapes was selected and analysed. Table VII gives the standard error between sub-plots and within sub-plot on unit basis, percentage information obtained and the estimated yield per unit. For the sake of comparative study, similar

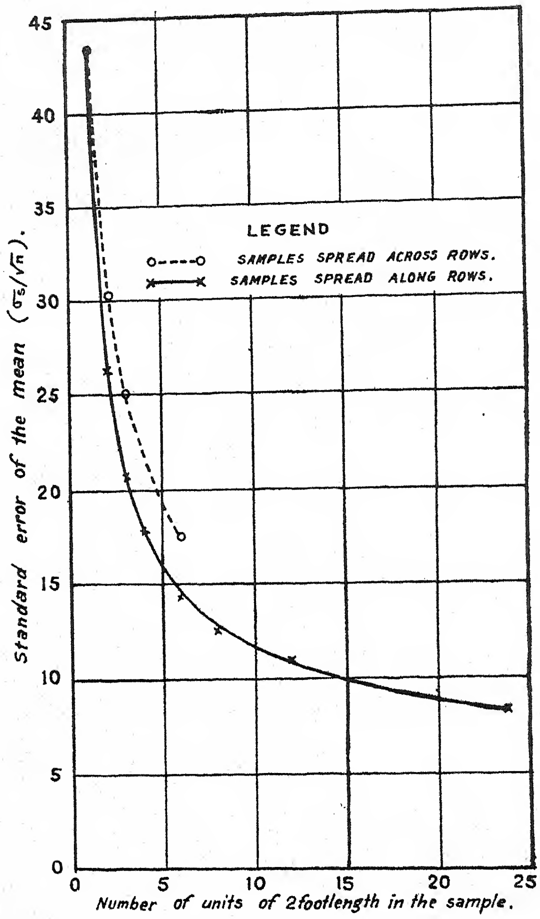


FIG. 2. Standard error of mean yield per 2 footlength of row $(\sigma_s/\sqrt{n})$ in relation to size and shape of samples,

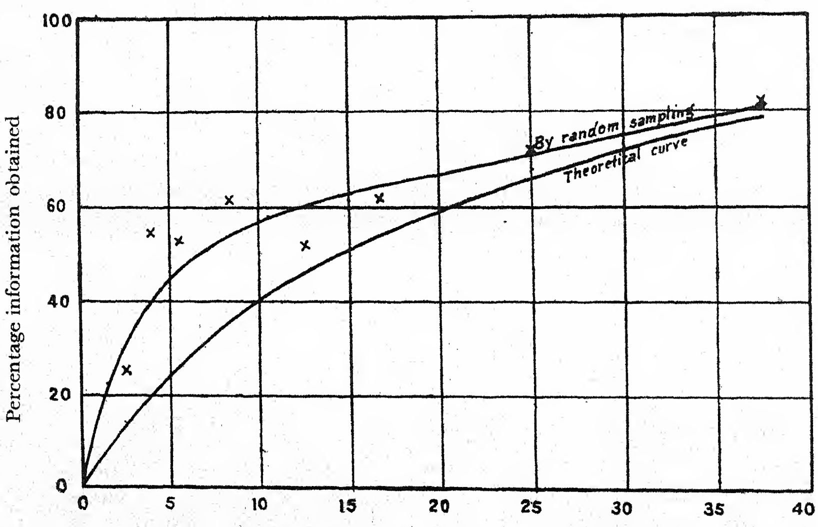


FIG. 3. Percentage information obtained in relation to the percentage of crop sampled, sample being four footlength of contiguous row.

TABLE VI

Results of Random Sampling of different percentages from sub-plots

Number of 4 linear foot-lengths sample from each sub-plot	Percentage of sub-plot sampled	Variance		Percentage information obtained		Mean yield for 4 foot-length as estimated sampling in 2 ozs.
		Between sub-plots	Within sub-plot	Actual	Theoretical	
2 ..	2·8	2727	2596	24·3	14·1	260
3 ..	4·2	6896	3926	55·4	20·5	260
4 ..	5·5	3283	1983	53·3	25·9	246
6 ..	8·3	7485	3808	61·8	35·0	258
9 ..	12·5	5034	3334	52·6	45·9	249
12 ..	16·6	4678	2573	62·5	54·2	255
18 ..	25·0	7135	3033	73·9	66·4	258
27 ..	37·5	7220	2524	82·1	78·1	250

Actual mean yield per 4 foot-length of row 225·6

TABLE VII

Results of random sampling with various sample sizes and shapes for 8·3 and 11·1 per cent sampling

Sample structure	No. of samples selected at random	Percentage sampled	Standard error per unit		Percentage information	Estimated yield in 1/8 lb. per unit length
			Between sub-plots	Within sub-plot		
1h × 2v	6	8·3	45·9	39·6	44·2	126·1
2h × 1v	6	8·3	62:9	39·5	70·2	129·1
1h × 3v	6	8·3	63·5	36·9	74·7	127·1
3h × 1v	6	8·3	40·8	33·6	49·2	120·8
1h × 4v	6	8·3	59·5	32·3	77·9	118·0
2h × 2v	6	8·3	52·9	37·5	62·3	127·2
4h × 1v	6	8·3	51·5	36·4	62·5	122·3
1h × 6v	6	8·3	57·9	56·9	25·0	130·9
2h × 3v	6	8·3	33·2	26·6	51·8	125·7
3h × 2v	6	8·3	52·3	47·5	38·1	129·0
6h × 1v	6	8·3	30·9	26·8	43·6	126·4
1h × 2v	9	11·1	54·5	45·6	49·9	125·5
2h × 1v	9	11·1	58·5	44·1	59·3	125·8
1h × 3v	9	11·1	49·9	44·7	42·6	127·6
3h × 1v	9	11·1	58·5	33·2	76·9	124·4
1h × 6v	9	11·1	56·2	35·1	72·1	121·6
2h × 3v	9	11·1	60·1	38·2	71·1	128·4
3h × 2v	9	11·1	56·6	32·5	76·4	126·0
6h × 1v	9	11·1	46·2	45·6	30·3	129·1

information for 11·1 percentage of sampling are also included in the table. In general, the percentage information is quite high and is of the order 60 to 70.

Discussion and Conclusion

In a complete enumeration of harvest experiment such as the present one, the most valid estimate of the error accrues from the variation between samples within a sub-plot, the samples being located at random. Hence the precision of the experiment increases by decreasing the variation from sample to sample within a sub-plot.

It is customary in the first instance, to test the frequency distribution for normality. In the present study, it was found that the distribution of the yields from units of two foot-length of row has significant skewness and kurtosis in the positive direction. However, these significant deviations from normality become insignificant in the distributions of yields from four foot-length of row obtained by combining the adjacent units. This clearly demonstrates that distribution for normality should be studied with yields from units of suitable size and not with yields from very small units such as two foot-length of row for sugarcane.

Size for size the sample elongated along the row has, in general, smaller variation than that spread across the rows. This is not in agreement with the findings of an earlier investigation carried out at Poona namely, "The samples comprising of 12 units in such a way that they include three to four rows in a sample, i.e., three units along rows or four units across rows or four units along rows and three units across form a suitable structure for estimating the yield of sugarcane". However, the present finding is in agreement with the earlier findings of the sampling studies for developmental observations. It is highly interesting to note that for the sugarcane crop, the samples elongated along the rows are less variable and hence more efficient while for the cotton crop, the samples spread across the rows are preferable. Perhaps this is so for the following reasons:

(i) the sugarcane crop is very much taller than the cotton crop, and

(ii) the rows of sugarcane crop are four feet apart while the rows of the cotton crop are 1½ feet apart. Hence one should expect greater competition between adjacent units in the same row than between rows in the sugarcane crop.

The standard error of the mean decreases rapidly with the increase in the sample size from two foot-length of row to eight foot-length of row and slowly thereafter (Table V). It is also found that 8·3 per cent sampling gives fairly good percentage of information (Table VI). Thus from the complete harvest experiment under discussion the following inferences may be drawn:

(1) The plots may be divided with advantage into two equal sub-plots along the row.

(2) Twelve units (two foot-length) may be sampled from each sub-plot.

(3) These twelve units may be combined to yield three samples of eight foot-length of row in each sub-plot and selected at random.

(4) The structure of this sample of eight foot-length of row may be four contiguous units from the same row.

(5) A sampling technique as stated above will on an average, give an estimated yield of 505 units in two ounces per eight foot-length of row with a S.E. of $35{\cdot}7\times\sqrt{4}$ (as there are four of two foot-lengths in the sample) i.e. 71·4 (Table V). Hence for an estimated yield from 36 such samples, percentage error will be of the order of $\frac{71{\cdot}4}{\sqrt{36}} \times \frac{100}{505} = 2{\cdot}4$ only.

The sampling technique that is employed at present in the co-ordinated crop-weather scheme relating to sugarcane crop is exactly the same as the inferences drawn from this complete harvest experiment namely the division of plots into two sub-plots along the row, sample size and structure and the intensity of sampling. Hence the present technique is, indeed, a very shrewd guess for the adoption 'in toto' of the findings in this paper.

Summary

1. The present paper deals with evolving a suitable sampling technique from a complete harvest experiment of sugarcane crop grown in the Agricultural College Farm, Poona in 1951-52.

2. The distribution of yields from two foot-length as well as four foot-length of rows are worked out.

3. The most suitable stratification of plots for sampling is the sub-division of plots into two equal sub-plots along the row.

4. The most efficient sample size and structure is a linear eight foot-length of row.

5. The amount of information obtained for various percentages of sampling and from various sample sizes and structure is given.

6. Lastly, a comparison of the findings from this paper with those of (i) findings from previous experiments and (ii) the sampling technique at present employed in co-ordinated crop-weather scheme relating to sugarcane, is made.

Acknowledgment

I wish to record my indebtedness to Dr. L. A. Ramdas for giving all facilities to carry out the experiment and for his guidance and to Shri A. K. Mallik, for his encouragement in writing out this paper.

REFERENCES

Ann. Rep. Co-ord. C. W. Scheme—(I.C.S.C. (1949). " Estimation of yield by sampling ".
———— (1949a). " Sampling for Developmental Observations ".
Clapham, A. R. (1929). " The estimation of yield in cereal crops by sampling method ". *J. Agric. Sci.*, **XIX.**
———— (1931a). " Studies in Sampling Technique: Cereal Experiments. I. Field technique." *Ibid.*
———— (1931b). " Studies in Sampling Technique. III. Results and discussion ". *Ibid.*, **XXI.**
Immer, F. R. (1932). " A study in sampling technique with sugar beets ". *J. Agri. Sci.*, **XXII.**
Kalamkar, R. J. (1932). " A study in sampling technique with wheat ". *Ibid.*, **XXII.**
———— Kadam, B. S., Satakopan, V. and Gopal Rao, S. (1943). " Studies in precision observations on Rice at Karjat ". *Ind. J. Agric. Sci.*, **XIII.**
Mallik, A. K., Satakopan, V. and Gopal Rao, S. (1945). " A study on the estimation of yield by sampling ". *Ind. J. Agric. Sci.*, **XV.**
Ranga Rao, D. S. and Sharma, V. G. (1957). " Pilot survey of sugarcane crop ". *The Farmer*—Sugarcane Number III-11.
Sreenivasan, P. S. (1942). " Studies on the estimation of crop growth and yield by sampling ". Part of M.Sc. thesis submitted to Madras University.
———— (1943). " Studies on sampling on tall crops like jowar ". *Ind. J. Agric. Sci.*, **XIII.**
———— (1950). " Studies in sampling technique: Efficiency of sample shapes for paddy ", *Ind. J. Met .& Geophy.*, **I.**
———— (1959). " A series of four complete enumeration experiments for the study of germination in sugarcane by sampling ". *Ind. J. Sub.cane Res. & Dev.*, **III.**
———— . " Studies in sampling techniques—Complete enumeration experiments on the cotton crop for estimating the growth characters (unpublished).
Yates, F. and Zacopanay, I. (1935). " The estimation of the efficiency of sampling with special reference to sampling for yield in cereal experiments ". *J. Agric. Sci.*, **XXV.**

CULTURAL EXPERIMENT TO INVESTIGATE THE INTER-RELATIONSHIP AMONGST THE FACTORS OF DEPTH OF PLOUGHING, TIME OF APPLICATION OF NITROGEN AND PLACEMENT OF PHOSPHATE

By

P. C. Raheja and K. P. Misra

(Indian Agricultural Research Institute, New Delhi)

Introduction

IN India, emphasis is laid on deep ploughing particularly for preparatory tillage of land for the sugarcane crop. Tractor ploughing is specially recommended for the purpose as the bullocks are heavily taxed to take the load of inversion of more than five inches depth of the soil. Heavy and medium power tractors are taken by the farmers with one of these objectives. It is, therefore, of national importance to determine how far deeper ploughing than five inches is beneficial for crop production. As the soil is turned over, the top soil, which has maximum bacterial activity, goes down and the latter less micro-biologically active soil with low humus content requires some time to come to the normal activity. Deeper the inversion longer is the time lag which occurs to attain normalcy. It is plausible to assume that full application of nitrogen would benefit the soil more under this treatment than split application and vice-versa on the shallow cultivated land.

It is different with phosphate, which is fixed in the calcareous and acidic soils soon after application. Placement is a suitable method of making phosphate available to the crop. Since response of nitrogen, in phosphate deficient soils, is modified by available phosphorus, the cultural practice of phosphate placement in the furrow was one of the factors included in the experiment. According to Splipher (1942) the problem of soil manipulation is both biological and dynamic in nature. It affects the retentive power of soil for water, the concentration of soil solution, air-exchange between soil, plant and atmosphere and uptake of nutrients. It is, therefore, evident that investigation of the complex relationship of depth of ploughing $\times$ time of application of nitrogen $\times$ phosphate placement factors is important from the point of view of efficient utilisation of fertilizers.

Review of Literature

During the last quarter of the 19th century enormous work had been done on the influence of the depth of tillage on yield of crops. The importance of deep cultivation to allow deeper root penetration preserving more moisture and large out-turn was stressed by many earlier workers (Goodale—1860 and Farrar and Sutton—1906). On the contrary Cardon (1915) and Sewell and Call (1920) observed that deeper cultivation conferred no benefit in increasing the yield of the crops. In Louisiana, deep versus shallow cultivation experiments for preparation of land did not show any desirable differences in the cane yield (Verret—1924); whereas, Turner (1932 and 1941) obtained significant responses in the yield of plant cane by soil inversion from tractor ploughed plots. Kerr's (1938) work in Queensland on sub-soiling versus ordinary cultivation indicated little advantage in favour of the former inspite of greater power consumption and labour cost.

Allen (1935), while reviewing the tillage experiments conducted in different states of India, concluded that there was no real evidence to support the belief that deeper tillage is essential to secure the best economical returns. He, however, recommended tillage with soil-inversion ploughs for irrigated crops like sugarcane, tuber and root crops with which it showed beneficial effect. In the case of light soils of Indo—Gangetic alluvium deeper inversion did not indicate any advantage as compared with '*Desi*' plough. Referring to the results of cultivation experiments conducted in the Punjab and else where Stewart (1941) concluded that the yields vary with the intensity of cultivation. Work of soil inversion plough is no better than the shallow-working '*Desi*' (local) plough. The main purpose of cultivation namely, control of weeds and value in conserving rain water for subsequent *rabi* (winter) crops are well served by repeated shallow cultivations. Patwardhan (1948) reported that at Padegaon, neither the cane yield nor its quality was superior in 11 to 12 inches deep ploughing treatment as compared with medium depth of tillage which ranged from eight to nine inches. Experiments conducted at Lyallpur, on the sugarcane crop, to compare

three different types of preparatory tillage with (i) furrow-turning+local plough; (ii) furrow-turning plough+horse-hoe; (iii) local plough only, for three years, did not show any significant differences in results—(Dutt—1950). Agarwala (1953) has recommended under U.P. conditions one or two ploughings with soil-inversion plough followed by six to seven ploughings with '*Desi*' plough for a good yield of sugarcane. Tabayoyog and Ferraris (1956) in Phillipines also did not find any significant differences between deep-ploughing and sub-soiling. Further experiments on cultural practices in Hawaii proved that mould-board plough is the most efficient tillage implement for land preparation (Anon—1958).

A large amount of conclusive evidence is available to show that placement of phosphate definitely improves the efficiency of response of the crop. After experimenting on *Panicum Sp.* grass Borden (1942) suggested that effectiveness of phosphate improved when placed in the sub-soil root-feeding zone and such placement is advantageous for deep root development. Ross (1948), at Trinidad found that moderate applications of super increased the action of ammonium sulphate in sugarcane crop. Sherrard (1948), while summarising the results of manurial trials conducted in the sugar belt in South Africa, found that the application of super @500-800 lbs. per acre as 'placement in furrow' gave the best results and was economical also. Experiments conducted at Padegaon, (1950-51) have indicated that placement of superphosphate at six inches depth in deep soils and half way down the ridge in medium soils has proved beneficial. The response to nitrogen was also found to increase with the placement of superphosphate. No conclusive benefit, however, accrued from depth placement of superphosphate at Shahjahanpur, Muzaffarnagar and Pusa. Lugo-Lupez and Martiniz (1952) have indicated that fertilizer applications at the rate of 2,000 lbs. per acre of 13:3:12 mixture in sugarcane, half of this quantity to the top soil and half the quantity to the sub-soil yielded significantly and economically higher than the top soil application. They have further indicated that the various types of sub-soil fertilization had no appreciable effect than ploughing of the surface soil alone, unless fertilizer was also applied in the sub-soil.

More recently, Shroo (1957) at Trinidad has indicated that for sugarcane, provision of sufficiently large contact area between the soil particles and root hairs and maintenance of good phosphate status in the contact zone increased the efficiency of phosphatic fertilizers. He advised that the fertilizer should be spread through the 12-inch layer around the plant. Surface application was inadvisable. Du Toit (1957) also reported that placement of super in furrow at planting had a residual effect on ratoon.

Investigations on the time of application of nitrogen have been carried out on sugarcane by several workers from two aspects, firstly in relation to efficient utilization by the crop and secondly the leaching out of the nitrogen in the lower soil-horizon. Verret (1927) noticed that the highest yield and the best juices were obtained from the plots receiving the earliest fertilizer. Rege *et al.* (1944) reported beneficial effect of nitrogenous application at germination, formative and grand growth period stages. Application of higher doses of nitrogen to the crop were not effectively utilized and some of the nitrogen leached out in the down layer of the soil. Raheja and Azeez (1948) found that the initial high dose application of nitrogen increased the tonnage of cane and total sugar yield. Rao and Narsinhman (1952) have indicated that the maximum need of nitrogen is in plants when they are $2\frac{1}{2}$-5 months old. Later application lowers the quality of the crop. Halais (1953) has found that the response to nitrogen is highest when 1/3 is given at planting and the rest when the crop is nearly 100 cms. high.

Experimental Details

Treatments and lay out of Experiment

The depth of ploughing × time of application of nitrogen × placement of phosphate experiment was started in 1948 and concluded in 1951. Two plant crops and two ratoon crops were raised. The treatments in the experiment consisted:—

Main plot treatments: Preparatory tillage of the land (C)

C_0—Preparatory tillage with 'Desi' plough (5 operations)

C_1—Ploughing with tractor 6″ deep inversion+two grubbings+two discings (5 operations)

C_2—Ploughing with tractor 10″ deep inversion+two grubbings and two discings (5 operations)

Sub-plot treatments:

(T) *Time of application of nitrogen (inorganic) @ 100 lbs. per acre as ammonium sulphate:*

T_0—Full dose at planting (placed in furrows)

T_1—Half dose @ 50 lbs. N per acre at planting+half @ 50 lbs. N per acre at first earthing up.

(D) *Placement of phosphates: 80 lbs. P_2O_5 per acre as Super:*

D_0—Broadcasting mixing

D_1—Placed in furrows opened for planting cane 5″ in depth.

Thus a split plot design with three main plot treatments and two×two sub-plot treatment was laid out in four replications. After the first ploughing in the three main plot treatments six weeks in advance of planting, a basal dose of F.Y.M. at the rate of ten tons per acre was applied. Thereafter four successive cultivations were given in C_0, C_1 and C_2. Before the forrows were opened for cane planting, superphosphate @ 80 lbs. P_2O_5 per acre was broadcast in D_0 plots of the experiment. The nitrogen and phosphate was placed at the bottom of the furrows. Setts were placed over it and these were covered by gatherer with moist soil by demolishing the side ridges.

The variety Co. 312 was planted in furrows opened with a furrower. Three budded setts were planted at the bottom of the furrow. The planting material was procured from the plant crop. The hoeing of the crop was carried out after every irrigation and earthing up operation was performed in the middle of July with the first monsoon showers. The second half application of nitrogen in T_1 treatment was applied immediately before the crop was earthed up. The data on germination, growth and tillering etc. were recorded during the life-cycle of the crop. The statistically analysed data along with the cane yield and juice quality are presented in the text.

Soil analysis

The figures in Table I indicate the composition of the soil in which the experiments had been conducted.

TABLE I

Depth of soil.	Physical composition.				pH	Humus %	Mean percentage of available nutrients.		
	Coarse sand.	Fine sand.	Silt.	Clay.			N	P_2O_5	K_2O
0–18″	0·75	80·70	7·42	10·08	7·26	1·425	0·032	0·028	0·125
19–36″	0·76	76·10	16·48	6·20	6·84	..	..	..	..
37–54″	0·46	69·50	11·22	16·88	6·59	..	..	..	..

These data show that the soils were sandy loam in nature even upto 54 inches depth in which the fine sand predominates. The reaction indicated is neutral. The humus content in the top soil is shown to be 1·425 per cent. which by no means is high. The soil had moderate level of fertility in respect of P_2O_5 and K_2O while nitrogen content indicated is low.

Irrigation and rainfall

The number of irrigations given to the different cane crops and the total rainfall received are given in Table II.

TABLE II

Year.	Total no. of irrigations.	Total rainfall in inches during the life-cycle.
1948-49 (Plant crop)	12	24·02″
1949-50 (Ratoon crop)	8	24·32″
1949-50 (Plant crop)	12	24·32″
1950-51 (Ratoon crop)	8	27·64″

The total number of irrigations given to each plant crop were 12 whereas in 'ratoon' cane the irrigations applied were eight. The total rainfall in inches received from March till next February for each crop varied from 24 to 27 inches.

Experimental Results

Effect of different treatments on the germination, linear development of mother shoots and tillering

The detailed figures are given in Appendix I. It is observed that the average germination of buds has not been significantly influenced by the different treatments, although during the second year of the experiment (1949-50), the cultivation treatment indicated significant differences and the 'shallow' ploughing (C_0) treatment exhibited significant increase in the germination of buds than the C_2 i.e. 10″ deep ploughing.

The average linear development of the mother shoot of the plant cane was not significantly influenced by the different sets of treatments. The ratoon cane exhibited significant differences during 1948-49 due to the cultivation treatment. However, in the two years' average the differences were small. The tillering capacity was not modified significantly due to any treatments during any year either for the plant or ratoon crop.

Effect on cane yield

The average yields of stripped cane in tons per acre are summarised in Appendix II for the individual as well as the average for both the years. The data of yields were statistically analysed for the various crops in different years and a combined analysis of plant and ratoon crops was done separately. The differences amongst the treatments in neither of the analyses were observed to be significant. The ratoon crop had not been manured at all. The residual effect on the treatments applied to the plant crop was observed. It is evident from the results that five cultivations with country plough were as good as the tractor operations. Deeper ploughing failed to increase the overall yields significantly inspite of the greater power consumption for field operations of deeper ploughings upto ten inches depth. The effects of different times of application of nitrogen and mode of application of phosphates also did not show significant differences.

Effect on Juice quality

The juice analyses of the samples from the cane crop planted in March 1948 were analysed in March 1949, and for the 1949 plant crop these were analysed in the 3rd week of February 1950. The samples of the ratoon crop of 1949-50 were analysed in February 1950 and 1950-51 crop in January 1951. The data have been summarised separately in relation to various factors under study. The data on the average of sucrose and purity percentages of juice are given in Appendix III.

The cultivation treatment did not indicate any significant variation in the juice quality, both in plant as well as ratoon cane.

In the case of different times of application of nitrogen also the differences were not significant except during the year 1949-50 (ratoon) where the split and late application induced significant reduction in sucrose than the earlier and full application of nitrogen.

The differences between the treatments of broadcasting superphosphate and placing in the furrows at the time of planting were neither significant in different years for the plant crop nor the residual effect was manifested on the ratoon crop.

Discussion

The differences in the yield of cane and the juice quality were not significantly influenced by the difference in the depth of initial tillage given to the soil. It is assumed that the soil-type in the experiment has been mostly sandy-loam, the importance of turning over the soil has been reduced and the process of soil inversion could not exhibit any marked differences in its favour over the shallow cultivation, most probably due to the fact that the soil did not differ much in its physical and chemical constitution as is obvious from the soil data given in the previous text. It is, therefore, concluded that light sandy soils may not need any deeper sub-soiling or inversion for the significant increase in cane yield. The reports of Stewart (1941) and experiment at Layallpur (Dutt, 1950) provide support to these findings.

So far as the time of application of nitrogen is concerned the late application has induced significant reduction in Juice quality, and it did not also benefit the cane yield. It is, therefore, presumed that split and late application of inorganic nitrogen under the present conditions of the experiment may not prove useful. The findings of Verret (1927) and Raheja and Azeez (1948) support the results.

The influence of placement of superphosphate has been supposed to have beneficial effect on the yield and quality of crops, but in this case the differences were not significant. It is presumed that under the present conditions of the experiment the phosphate availability might have been optimum under both the placed and broadcast applications.

Summary

A three × two × two factorial experiment was conducted at Indian Agricultural Research Institute, New Delhi on sugarcane variety Co. 312 with three different depths of cultivation treatments (1) shallow five to six inches depth with ' country ' plough (non-inversion) (2) Tractor plough six inches deep inversion + grubbing and discings (3) tractor plough ten inches deep inversion + grubbing + discings; two times of application of nitrogen (i) Full at planting 100 lbs. N per acre as Ammonium sulphate and (ii) half at planting + half at earthing up and two modes of application of phosphates (a) as broadcast application and (b) as 'placement' in the bottom of the furrow, during 1948-49 and 1949-50 on plant cane and their residual effect studied on 1949-50 and 1950-51 ratoon crops respectively. The soils were sandy loams (alluvial) with normal pH.

The results are summarised as under:

(1) Deep preparatory tillage upto ten inches of the soil does not confer any benefit to the crop grown there. The improved structure built by soil inversion as compared to mere cultivation have neither improved the yields of plant and ratoon crops nor their quality.

(2) Dividing the dose of 100 lbs. nitrogen into two halves and applying half at planting and half at earthing up did not indicate any significant increase in the yield on the average; although it indicated significant differences during the second year of the trial. Full dose application indicated higher sucrose and purity per cent than by dressing half of the dose in the boom stage of the crop. This late application of nitrogen at earthing up appears to have delayed the maturity although it benefited growth of the plant as well as ratoon crop.

(3) Furrow placement of superphosphate had little beneficial effect on yield and quality of both the plant and ratoon canes. Slightly higher sucrose content was observed in juice by placing superphosphate in the furrow, though the purity was not affected by this treatment.

In general, shallow cultivation of the soil, placement of phosphate in the furrow and full dose application of fertilizer have indicated better results than otherwise.

Acknowledgments

The authors are grateful to Dr. T. J. Mirchandani, M.Sc., Ph. D., Head of the Division of Agronomy, I.A.R.I. for providing necessary facilities for conducting the experiment. The three post-graduate students associated with this experiment were Messrs. R. C. Garg, B. P. Singh and G. N. Misra in three different years. Their assistance is acknowledged.

REFERENCES

Anonymous (1919). Sub-soiling versus ordinary cultivation. *Ann. Report Bur. Sugar Expt. Sta. Queensland*: 29.
——— *Annual Report Sug. Res. Sta., Padegaon*, 1950 and 1951.
Agarwala, G. D. (1953). Sugarcane cultivation in the U.P. Suggestion for improvement. *Indian Sugar*, **3**: 65-68.
Allen, R. G. (1935). Remarks on primary cultivation under Indian conditions with special reference to soil inversion. *Agric. & Livestock Ind.*, **5**: 351-81.
Borden, R. J. (1942). Are there possibilities in sub-soil fertilization. *Hawaiian Plant Rec.*, **46**: (2) 59.
——— (1942). The first application of nitrogen. *Hawaiian Plant Rec.*, **46** (3): 103.
——— (1950). A survey of plantation fertilizer practices. *Hawaiian Plant Rec.*, **53**: 191-93.
Cardon, P. V. (1915). Tillage and rotational experiment at Niphi, Utah. *U.S.D.A. Bull.*, **157**.
Cornellison, A. H. and Cooper, H. F. (1941). Further studies in nitrogen nutrition time of application of nitrogen test. *Hawaiian Plant Rec.*, **45** (3): 155-78.
Du Toit, J. L. (1957). Fertilizer responses as revealed by exploratory trials. *S. African Sug. Jour.*, **41**: 213-23.
Dutt, N. L. (1950). Report on Survey of Sugarcane Research in India. *Ind. Cent. Sug. Committee Publication.*
Farrar, W. and Sulton, G. E. (1906). Ploughing with mould board and disc ploughs. *Agric. N.S.W.*, **17** (4): 320-26.
Goodale, G. L. (1860). Underground drainage and deep tillage. *Main Abst. Returns from Agric. Sec.*, **122**-38. (Original not seen).
Hockensmith, R. D. *et al.* (1933). Effect of placement on the availability of superphosphate in calcareous soils. *Soil Sci.*, **36**(3).
Hopkins, D. P. (1949). The phosphate studies. *World Crops*, **1** (3): 108-18.
Kerr, H. W. (1938). Intensive cane production, *I.S.J.*, **40**: 47.
Lugo-Lupez, M. A. and Martiniz, M. B. (1952). "Fertilizer placement affects sugarcane" *Agric. Engi.*, **33**: 548.
Lugo-Lupez, M. A. and Martiniz, M. B. (1952). "The influence of sub-soil fertilization on the sugarcane yield" *Sug. J. Manila*, **15** (7): 24-27.
Miles, R. O. (1947). The placement of fertilizers. A summary of the present state of knowledge on the subject in Great Britain. *Jealleot's Hill Res. Sta. Bull.*, No. **4**.

Patwardhan, G. K. (1948). Ploughing, its depth and frequency. Effect on growth and yield of cane. *Ind. Sugar*, **11**: 169-72.
Raheja, P. C. and Azeez, M. A. (1948). Analysis of Agricultural yields. I. Multiple factor experiment on spacing, nitrogen doses and time of application of nitrogen. *Ind. J. Agri. Sci.* **18** (2):113-22.
Rege, R. D. (1944). Problems of sugarcane physiology in the Deccan Canal tract:, IV. Mineral nutrition: Nitrogen. *Ind. J. Agri. Sci.*, **14** (1): 1-18.
Ross, R. (1948). Sugarcane Expt. in Trinidad. *Proc. Agric. Society, Trinidad*, **48**: 271-72.
Sewell, M. C. and Call, L. E. (1920). Tillage investigation relating to wheat production. *Kansas A.E.S. Tech. Bull.*, **18**.
Sherrard, C. D. (1948). A summary of the results of manurial trials in the sugar belt. *Proc. Congress S. African Sug. Tech. Asson.*, **22**: 119-226.
Splipher, J. A. (1942). The mechanical manipulation of soil as it affects the structure. *Agric. Eng.*, **13**.
Stewart, A. B. (1941). Report on soil fertility investigations in India with special reference to manuring. *I.C.A.R. Pub.*
Turner, P. E. (1932). Cultivation experiments with sugarcane. I. The preparatory tillage on the yield of plant canes. *Proc. Int. Soc. Sug. Tech. 4th. Congress, Puertorico Bull.*, **15**.
———— (1941). Field experiments in Sugarcane in Trinidad. *Trop. Agric.*, **18** (7): 140-43.
Verret, J. A. (1924). Cultivation practices. *Hawaiian Plant Rec.*, **28**: 29.
———— (1927). Early fertilization gives better juices. *Hawaiian Plant Rec.*, **31** (2).

APPENDIX I

Effect of different treatments on the average germination of buds, linear developments of main shoot and tillering of sugarcane

Treatments	Mean no. of germinated buds per plot (1/40 acre)			Linear development of main shoot (Height in cms.)						Average no. of tillers per main shoot					
				Plant Crop			Ratoon Crop			Plant Crop			Ratoon Crop		
	1948–49	1949–50	Mean	1948–49	1949–50	Mean	1949–50	1950–51	Mean	1948–49	1949–50	Mean	1949–50	1950–51	Mean
C_0 ..	285·8	316·0	300·9	195·3	213·7	204·5	195·3	197·0	196·1	3·29	3·17	3·23	8·10	6·60	7·35
C_1 ..	337·5	299·6	318·5	186·3	220·9	203·6	180·0	202·1	191·0	2·80	3·20	3·00	7·90	6·10	7·00
C_2 ..	336·9	282·2	309·5	183·7	219·4	201·5	173·3	203·3	188·2	2·78	2·96	2·82	5·30	5·90	5·60
'F' test ..	Not sig.	Sig. 5%	Not sig.	Not sig.	Not sig.	Not sig.	Sig. 5%	Not sig.	Not sig.	Not sig.	Not sig.	Not sig.	Not sig.	Not sig.	Not sig.
S.Em. ..	±17·33	±6·99	±13·33	±10·99	±4·73	±8·22	±2·39	±3·33	±0·31	±0·39	±0·27	±0·37	±0·46	±0·39	±0·44
C.D. 5% ..	..	24·06	..	..	..	..	6·90	..	..	..	..	..	..	..	..
T_0 ..	330·6	291·8	311·2	185·4	216·5	201·9	184·1	198·6	191·8	2·98	3·00	2·99	8·00	6·00	7·00
T_1 ..	312·2	306·8	309·5	191·2	219·5	205·3	181·6	202·9	192·2	2·90	3·21	3·08	7·60	6·60	7·10
'F' test ..	Not sig.	Not sig.	Not sig.	Not sig.	Not sig.	Not sig.	Sig. 5%	Not sig.	Not sig.	Not sig.	Not sig.	Not sig.	Not sig.	Not sig.	Not sig.
S.Em. ..	±5·74	±5·72	±5·83	±9·87	±3·97	±6·92	±1·58	±2·29	±2·06	±0·32	±0·17	±0·29	±0·14	±0·13	±0·14
C.D. 5% ..	..	..	..	..	..	..	4·54	..	..	..	..	..	..	..	..
D_0 ..	326·0	298·7	312·3	187·9	216·7	202·3	180·6	201·2	190·9	2·90	3·01	2·95	7·80	6·20	7·00
D_1 ..	325·4	299·7	312·8	188·7	219·2	203·9	185·2	204·4	194·8	3·02	3·20	3·11	7·80	6·40	7·10
'F' test ..	Not sig.	Not sig.	Not sig.	Not sig.	Not sig.	Not sig.	Sig. 5%	Not sig.	Not sig.	Not sig.	Not sig.	Not sig.	Not sig.	Not sig.	Not sig.
S.Em. ..	±5·94	±5·72	±5·82	±9·87	±3·97	±6·92	±1·58	±2·29	±2·06	±0·32	±0·17	±0·29	±0·14	±0·13	±0·14
C.D. 5% ..	..	..	..	..	..	..	4·54	..	..	..	..	..	..	..	..

APPENDIX II

Effect of different treatments on cane-yield

(Average yield of stripped cane in tons per acre)

Treatments	Plant Crop			Ratoon Crop		
	1948–49	1949–50	Mean	1949–50	1950–51	Mean
C_0	25·1	26·1	25·6	18·8	15·0	16·9
C_1	26·8	26·2	26·5	19·0	13·3	16·1
C_2	24·7	27·0	25·8	17·9	13·1	15·5
'F' test	Not sig.	Not sig.	Not sig.	Not sig.	Not sig.	Not sig.
S.Em.	±1·15	±0·47	±0·87	±0·63	±0·44	±0·80
'F' test for seasons	Not sig.			seasons sig. at 1%		
				S.Em.=±0.67		
				C.D. 5%=1.91; 1%=2.55		
S.Em.	±0·76					
T_0	25·5	26·0	25·7	18·4	13·6	16·0
T_1	25·5	27·0	26·2	18·8	13·9	16·3
'F' test	Not sig.	Sig. 5%	Not sig.	Not sig.	Not sig.	Not sig.
S. Em.	±0·95	±0·33	±0·71	±0·77	±0·65	±0·71
C.D. 5%	..	0·98	..	..	..	..
D_0	25·6	26·4	26·0	18·5	13·4	16·0
D_1	25·3	26·4	25·9	18·7	14·1	16·4
'F' test	Not sig.	Not sig.	Not sig.	Not sig.	Not sig.	Not sig.
S. Em.	±0·95	±0·33	±0·71	±0·77	±0·65	±0·71

Appendix III

Effect of different treatments on juice quality

Crop	Crop Season	Sucrose or Purity%	Date of analysis	Treatments			'F' test	S.Em	C.D. 5%
				C_0	C_1	C_2			
Plant ..	1948–49	Sucrose	Mid-March	17·75	18·05	18·35	Not sig.	±0·41	..
		Purity	1949	89·8	90·6	90·6	Not sig.	±0·97	..
Plant ..	1949–50	Sucrose	Late Feb. 1950	16·36	15·92	16·01	Not sig.	±0·38	..
		Purity		88·5	87·3	87·3	Not sig.	±1·08	..
Ratoon ..	1949–50	Sucrose	Mid-Feb. 1950	15·72	15·29	15·32	Not sig.	±0·24	..
		Purity		85·8	84·4	84·7	Not sig.	±0·58	..
Ratoon ..	1950–51	Sucrose	Late Jan. 1951	14·87	14·73	14·44	Not sig.	±0·27	..
		Purity		82·0	80·7	79·7	Not sig.	±1·11	..
				T_0	T_1				
Plant ..	1948–49	Sucrose	Mid-March	17·99	18·12	..	Not sig.	±0·34	..
		Purity	1949	90·0	90·6	..	Not sig.	±0·76	..
Plant ..	1949–50	Sucrose	Late Feb. 1950	16·19	16·01	..	Not sig.	±0·31	..
		Purity		88·1	87·5	..	Not sig.	±0·93	..
Ratoon ..	1949–50	Sucrose	Mid-Feb. 1950	15·64	15·25	..	Sig. 5%	±0·086	0·26
		Purity		85·5	84·3	..	Sig. 5%	±0·44	1·13
Ratoon ..	1950–51	Sucrose	Late Jan. 1951	14·72	14·64	..	Not sig.	±0·26	..
		Purity		81·1	80·4	..	Not sig.	±0·89	..
				D_0	D_1				
Plant ..	1948–49	Sucrose	Mid-March	17·88	18·22	..	Not sig.	±0·34	..
		Purity	1949	89·57	91·1	..	Not sig.	±0·76	..
Plant ..	1949–50	Sucrose	Late Feb. 1950	16·15	16·04	..	Not sig.	±0·31	..
		Purity		87·8	87·7	..	Not sig.	±0·93	..
Ratoon ..	1949–50	Sucrose	Mid-Feb. 1950	15·49	14·40	..	Not sig.	±0·086	..
		Purity		85·5	84·3	..	Not sig.	±0·39	..
Ratoon ..	1950.51	Sucrose	Late Jan. 1951	14·62	14·73	..	Not sig.	±0·26	..
		Purity		80·2	81·4	..	Not sig.	±0·87	..

THE BEST RATOON

By

SHANKARRAO ADHATE

(Louisiana State University, Baton Rouge, La., U.S.A.)

IT is very surprising to know that many countries growing sugarcane depend on their ratoon crop. The countries like Nationalist China, Australia, and U.S.A. take 2-3 ratoons, while Mauritius and Natal in South Africa take 4-5 ratoons. Cuba takes 10-11 ratoons and there are instances where farmers are taking 25 ratoon crops. The other countries like Philippines, Hawaii, Brazil, and Puerto Rico are also taking 2-3 or more ratoons. Ratooning of cane requires no green manuring and not too much preparation of land. It saves at least two to three tons of cane for planting an acre and thus it is more economical. Some farmers have the wrong idea that ratoon is not high yielding; on the contrary, it gives equal or higher yields than the plant cane in some countries.

In Australia, there was nearly 75 per cent of total sugar cane crop under ratoon in Babinda region in 1957 which had 28 per cent of total cane area in Australia. In South Africa including Mauritius there was 72 per cent of the cane area under ratoon in 1955-56. Realizing the importance of many ratoons, Taiwan (Formosa) has recently started to take more than two ratoons. And there was more than 32 per cent of the total area under ratoon in 1956 and it is increasing every year.

South Africa in 1955-56 season harvested nearly 200,000 acres of cane and the yields of several ratoons are as below (Dutoit, 1958).

	Plant Crop	1st. Ratoon	2nd. Ratoon	3rd. Ratoon	4th. Ratoon
Per cent area	27·9	31·1	26·0	11·2	2·8
Cane tons/acre	40·3	30·1	29·6	28·3	32·1

Mauritius sugar estates comprising more than 100,000 acres have obtained the following yields from various ratoons in the 1955-56 season (Kerr, 1958).

	Plant Crop	1st. Ratoon	2nd. Ratoon	3rd. Ratoon	4th. Ratoon	5th. Ratoon
Cane Tons Per acre	36	35	33	31	30	30

Taiwan (Formosa) has obtained the following yields from this newly started method in 1955-56 on 32 per cent of their cane area (Liu, 1958).

	Plant Crop	1st. Ratoon	2nd. Ratoon	3rd. Ratoon
Cane Tons/Acre.. ..	32	27.2	26	24

One may think that the yields obtained are not very high, but under the circumstances prevailing in the countries, the ratoon yields may be compared with their plant crop; and because in countries like Australia, Hawaii, and Louisiana (U.S.A.), the farmer owns a big cane plantation which is sometimes unmanageable. But a well cared ratoon generally yields a little more than the plant crop. A large scale trial gave the following results in Louisiana (Matherne, 1957).

The cane when ratooned not only gives more tonnage for the first ratoon but for the successive ratoons also, and the tendency in cultivators is increasing for growing more area under ratoon and for increasing the number of years of ratoon.

Sugarcane varietal trial in Louisiana (1956) *on large plots*

Variety	Cane Tons/Acre	
	Plant Crop	Ratoon
N. Co. 310	28·36	34·01
C. P. 44/101	27·82	32·83
C. P. 48/103	22·18	26·49
C. P. 47/193	22·05	30·57
C. P. 36/105	28·13	27·33
C. P. 44/155	23·61	25·73

In Louisiana, the cane is planted in September and October, but cane has its upper parts killed in the winter; and after March the underground part starts growing. In next October and November it is harvested, because of fear of frost or snow fall; juice may freeze and crushing may not be possible if kept longer. Considering that cane grows in adverse conditions, with staisfactory period of only eight to nine months, the yields may be said very high. Similar yields in Australia were obtained when different varieties were ratooned.

A farmer, Mr. J. L. William, in South Africa harvests 400 acres of cane every year with very little area under plant crop. Up to 1956-57, he obtained the following average yields from plant and many ratoons on various divisions of his farm as below (Annonymous, 1957).

Cane Tons/Acre

	A	B	D	F	G	I	K	M
Plant Crop	41·5	34·0	36·0	34·0	33·6	34·0	32·0	36·0
1st. Ratoon	57·3	33·3	43·3	43·3	43·2	46·0	37·0	46·0
2nd. Ratoon	70·0	40·0	57·0	60·4	60·0	51·0	47·0	50·5
3rd. Ratoon	..	59·0	..	..	..	..	64·4	55·5

All these above figures show an increase in yields over the previous yields. The yields from Mr. William's fields are nearly 100 per cent more over that of plant crop even in case of third ratoon. This makes Mr. William to say, "Why plough out" such ratoonable fields. There remains no doubt that two to three ratoons may yield equally good or even better than the plant cane and farmers should start ratooning their cane with proper care to get more yields.

But sometimes ratoon may give less yields under some conditions. Plant cane having very uneven, poor crop with small number of canes should not be ratooned, as ratoons may yield less because of little plant population in ratoon. Therefore, it is necessary to take care in preparing land to have good germination in plant crop. Care should be taken for selection of good seed material and giving seed treatments for good germination. Irrigation, manuring and weed control measures are also of great importance in cane yields. A cane attacked by insects and diseases may increase the trouble not only in the same fields but also in the neighbouring ones. Such ratoon crop will be very poor and will yield low tonnage. Late harvesting or shallow cutting of the previous crop may cause an adverse effect on ratoon. For example, crop harvested in February, will get very little period for growth, as growth is stopped after flowering in October or November. However, flowering is a varietal character and is affected a little by other factors also. If crop is harvested early, and ratoon prepared late, similar effects or even worse will occur. Another most important factor is the depth of harvesting. If harvested only from the surface of the ridge, it will be necessary to shave the stubbles deep. In case of uneven crop, some new setts may be planted in the gappy places as early as possible. But if the crop is attacked by insects or by some diseases like red rot, rust, smut, mosaic or ratoon stunting, it is better to plough out and clear the whole field (Chou, 1957). Some of the above points are discussed in brief in the following paragraphs.

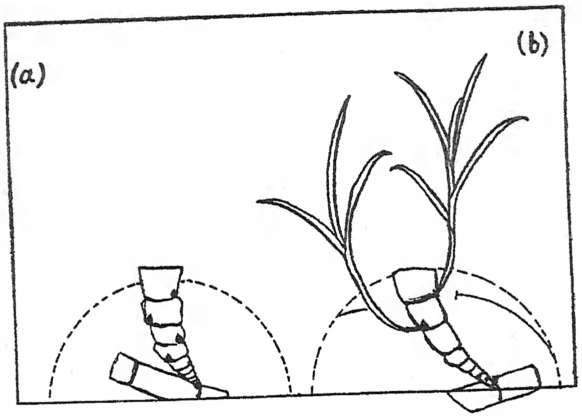


Fig. 1

a. Shallow harvest *b.* First ratoon probable soil support at earthing up

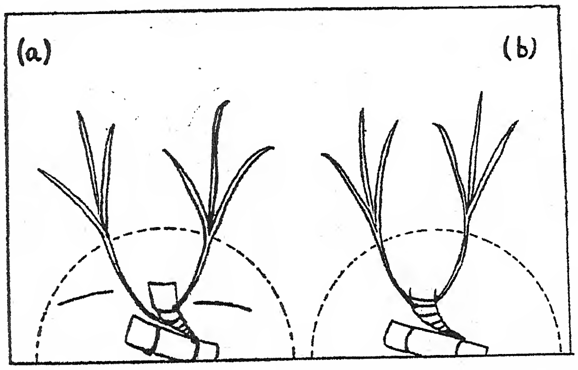


Fig. 2

a, b. 1st ratoon of deep harvest

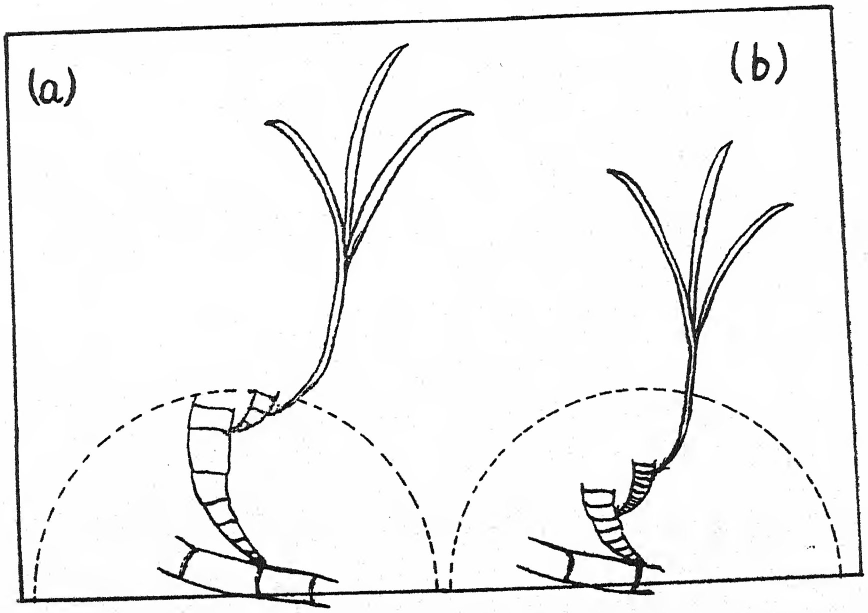


Fig. 3

a. Second ratoon of shallow harvest *b.* Second ratoon of deep harvest

For example, in Deccan Canal tract, the harvesting starts from October or earlier, and ends in February and March. There are three types of plantings, namely, January planting, July planting and October planting, adjusted to give the cane crop the maximum period for growth which is limited by flowering. Flowering usually takes place in October or November. It is interesting to see how the different plantings grow and yield in response to growth period they get up to flowering.

Plantings	Period of Growth (Up to Flowering)	Millable or Mature Height	Yields of Cane (Tons per acre)
January planting ..	9½–10	90″–95″	45–50
October planting ..	11½–12½	110″–115″	55–60
July planting	14½–15½	140″–150″	65–70

The figures given above are moderate and approximate. They indicate that sugar cane yields nearly the same if calculated on monthly basis. On an average, cane gives 4½-5 tons of cane per acre in a month. But usually the losses will be more for late start of ratoon, as the growth is not uniform in all months, and because the first three months yield no millable cane.

Late harvesting after October, means reducing the number of months of growth of ratoon crop and losing nearly 4½-5 tons of cane/acre for every late month. Even a week's delay means at least a loss of one ton of cane/acre. Therefore, it is necessary to avoid delay in collecting trash, stubble shaving and preparing the land. As far as possible, the trash collecting may be done simultaneously with harvesting. Deep harvesting will also serve the same purpose as of "Deep" stubble shaving. Only early harvesting has no meaning unless above two operations are carried out; and furrows are broken and cultivated deep. The cane harvesting depends on the maturity. Maturity in turn depends upon the variety, manuring, irrigation, etc. But it is not so much associated with the flowering. Generally July planted crop will mature in October; October planted in November and January planted in December. To delay in harvesting the crop which has reached the peak in sugar content, is a waste of sugar; as it tends to come down if kept for a longer time. Thus the July and October planted crops are the best as far as the ratooning is concerned, as their ratoons will get nearly 10-12 months for their growth, and will yield nearly 50-60 tons of cane per acre. If harvested early, the land should be prepared early. This item is many times neglected in Deccan Canal Tract. The best way is to remove the trash as the harvesting is in progress. The upper buds sprout within 10-15 days even if the trash removal or stubble shaving is not carried out early. The stubble shaving can be satisfactorily done only when the land is well cultivated between the rows. Late stubble shaving allows the stubbles to sprout, and some energy and food material is wasted, and then ratoon depends on the second sprouting of the deep placed buds. The second sprouts may not be so even, healthy and strong as the first ones. Sometimes, stubble fails to give out new sprouts if shaved late. This leads to weak and to less number of millable canes in the ratoon crops. The knives used for harvesting and stubble shaving must be very sharp. Blunt knives may cause injuries and bruises to the stubble. The bruises to stubbles result in the fermentation of the sucrose in the stubbles and then the stubbles die away. Moreover, with blunt knives, harvesting and shaving may not be deep enough, which may entail upon the yields of the ratoons. Over all 2″-2½″ shallow harvesting means a loss of one ton of cane per acre.

"Deep" stubble shaving is one of the most important operations to have a good ratoon crop. Taiwan Sugarcane Research Station reports on an experiment conducted on stubble shaving that the deep shaving gave 48 tons of cane while the shallow stubble shaving gave 20·4 tons of cane per acre in the first ratoon (Choul, 1952). When these canes were further ratooned, they got 8 tons of cane per acre more by deep stubble shaving. The deep shaving gave tall, erect, heavy canes while the shallow shaving gave leaning, short and poor canes. And this is why, at present ratoon on the Deccan Canal Tract does not give a good attractive yield. But it lodges very early, giving further decrease in growth of cane and sucrose contents. As a matter of fact, ratoon grows faster and more than the plant crop and matures early. The reason for lodging and poor growth of cane in the shallow shaved ratoon is obvious. The upper buds on the stubbles sprout and lower ones remain dormant because of epical dominance. The canes so formed are high placed with poor root system and having very little support of soil. Earthing-up of such crop will very rarely be helpful to it. Roots may not reach the proper depth of soil and tillers may die away in shallow shaving. The ratoon is not able to get sufficient food material because of shallow root system. If such a ratoon is ratooned second time, deep stubble shaving is practically impossible and sprouts will arise just from the few upper buds on the surface of the ridges as there will be little or no stubble left in the ground and thus the subsequent ratoons are badly affected. And this is the reason for getting poor yields for first and other ratoons on Deccan Canal Tract. As a matter of fact first ratoon is not still popular among the farmers, not because their soil, climatic

or other factors are adversely affecting, but because of easy-going methods, shallow and late stubble shaving. Stubble shaving should be done before they sprout.

There are certain reasons why Deccan Canal farmers avoid deep stubble shaving. They have no machines for this operation. Other countries like Louisiana, Australia, Mauritius and Hawaii use a machine, " Stubble Shaver ". This machine cultivates 10"-12" deep in the furrows, breaks the sides of the ridges, and shaves the stubbles 6"-7" deep below the ridge surface.

Heavy ridges for sugarcane crop and its earthing-up, may be another reason for shallow shaving of the stubbles. Some countries and in some parts of India, people burn the trash to hurry up the ratoon operations, and also to kill the upper buds of the stubble, and allow to sprout the deeper ones. But it cannot equal to the deep shaving. Moreover some organic matter in the sail is lost because of burning the trash. But this operation can equally be done well by manual labour. A point which can save the labour, at the same time which can add 2-2½ tons of cane per acre to the yield of the crop harvested, may be suggested in this matter. A gang of 15-20 labourers may be employed to break open the ridges 7"-8" below the ridge crest, prior to the harvesting. This will enable the labourers to harvest the cane at least 7"-8" below its usual point. This addition of 7"-8" of cane all over will give 2-2½ tons of cane per acre, at the same time no operation like stubble shaving will be necessary. Further operations for preparing land can be done after removing the trash as early as possible. Cutting so deep is not harmful to the ratoon. There will be still a stubble 4"-5" with 6-7 buds left in the ground, and sprouting of 2-3 buds and survival of even one will be quite sufficient to maintain the moderate plant population 40,000-42,000 canes per acre for high yields. By deep cutting, few buds will sprout into good healthy tillers. Shallow cutting allows sprouting of many upper buds. Sometimes, the population goes over 200,000 up to earthing-up with high mortality after earthing-up; and such a ratoon gives less number of millable canes at harvest and ultimately the low yields. Deccan Canal Tract has deep furrows for planting. And heavy earthing-up buries the 10"-12" of millable cane length in the soil, and at least 7"-8" of these buried canes can be harvested the above way. Even the remaining stubbles still left along with roots is a big quantity of organic matter which will go under decomposition. According to Dr. Dillewijin (1952), quantity would be 11-12 tons per acre. In case of a cane crop of 46 tons/acre, it will have 14 tons of tops per acre. And 18-19 per cent of the total of the above constituents will be (11-12 tons/acre) left in the ground in moderately earthed up crop. Perhaps, in Deccan, the furrows are deep, and cane portion left in the ground would be quite long. And there would be a large amount of undecayed organic matter in the soil, when such field is ratooned. Soil micro-organisms will lock up lot of food material from the soil until the decomposition is in progress, and the ratoon will be underfed. To reduce this effect, it is necessary to remove away some of the stubble quantity by way of harvesting cane deep or deep shaving; and by giving extra 50 lbs. of nitrogen/acre merely for organic decomposition.

Preparation of soil consists of breaking of ridges without injuries to the stubbles, and deep working of the furrows up to a depth of 6-7 inches. The soil is made loose, friable with fine tilth with subsequent cultivation by some suitable harrows and cultivators. Serpentile method of layout will not be a good one for plant and ratoon crops. Especially this type of cultivation by bullock implements in ratoon will be possible in only straight furrow methods of layout. The stubbles are shaved deep as soon as they are exposed 6-7 inches. The soil will become hot, and deep buds will become active. Such sprouts will be strong and vigorous. There will be good aeration in the soil. If the previous crop is harvested deep, *stubble shaving may be avoided.* Ratoon is exactly identical with plant cane and its needs are similar to those of plant cane.

Some farmers regard the ratoon crop as a " God's Gift ", and thus neglect it, and harvest what has grown. No doubt it is a " God's Gift " as it saves land, requires no green manure; about 2½-3 tons of seed cane material and some labour for planting is saved. Land preparation of ratoon is an easy item as considered to that of plant cane. With all these benefits, farmers are still tempted to reduce the quantity of fertilizers. According to Dr. Stubbs (1897), ratoon requires more manure to have good yields.

Other countries give not only as much fertilizers to ratoon as they give to the plant crop, but also give some 50-60 lbs. of extra nitrogen/acre, and phosphate and potash as the experiments decide. But response of sugarcane to nitrogenous fertilizers is great and world wide. If one goes through the book " Manuring of Sugarcane " by D. J. Halliday (1956), he would find that Barbados, Br. Guiana, Peru, Louisiana, Brazil and Australia, on the basis of field experiments fertilize ratoon liberally and they are, therefore, able to maintain equal or higher yields of ratoon. An interesting example may be cited here of an experiment conducted by the Department of Agronomy of the Louisiana State University, Baton Rouge. For clarity yields of only common and few higher manurial doses for plant and two ratoons are given below (Byrnside *et al.*, 1955, 1956, 1957).

Yield of plant cane for treatment No. 4 seems to be erratic. The figures indicate that when same doses as to the plant cane are given to the ratoon, the difference in the yields of plant, 1st ratoon and second ratoon are large. If increased doses are given to plant crop, first and second ratoons, their yields are increased

Doses in lbs/Acre	Plant Cane	1st. Ratoon	2nd. Ratoon
N-P_2O_5-K_2O			
0–0–0	18·50	14·93	12·19
60–0–0	23·12	18·42	..
60–0–60	22·16	18·61	..
60–40–60	26·68	18·73	..
80–0–0	23·79	18·98	19·36
80–0–60	24·28	20·27	20·47
*80–40–60	23·41	20·77	18·74
100–0–0	..	20·81	20·47
†100–40–60	..	22·83	22·57

*Recommended dose for plant crop.
†Recommended dose for ratoon crop.

markedly, and differences in their yields become narrow. When ratoons receive higher doses than the plant crop, then their yields are nearly equal. This research station has conducted many such experiments on various soil types in which higher doses to ratoons gave higher yields than that of the plant crop. Mohanrao (1956) also is of the opinion that ratoon requires higher doses than the plant crop to maintain the yields. Some people are of the opinion that the plant crop leaves big fertilizer residues, and that the ratoon need not be fertilized with such high doses. But it seems unwise to fertilize plant crop with high doses, and for ratoon, though it is of equal yield potential to rely upon the residual effects. A dose of fertilizer given in time even with little less quantities would be more effective than the assumed residues. Dr. Dillewijin (1952) is of the opinion that the sugarcane leaves no substantial residues of fertilizers. It is a well known fact that P_2O_5 and K_2O are fixed up in soil to a great extent, and one should not expect much of residual effects of such fertilizers. In case of nitrogenous fertilizers, they are also fixed up to little extent, but their loss is mostly through leaching and volatilization. The quantities of N, P K fertilizers for plant and ratoon vary in different regions depending upon soil type, organic matter and nutrient contents, growth period and other factors. A thirty ton cane crop absorbs 96 lbs. of nitrogen, 54 lbs. P_2O_5, and 199 lbs. of K_2O per acre from soil and manuring should be adjusted to supply N and P_2O_5 mostly from the fertilizers, and K partly from soil and partly from fertilizers. For ratoon, first dose containing a little large quantity of nitrogenous fertilizers and full quantities of P K fertilizers may be given 6″-7″ deep in the sides of the rows at the time of the first irrigation. This may be done by making a small furrow by suitable implements or drill and then covered. Second and third doses are given similarly, but the interval between the doses will generally depend upon the growth period of the crop. And further operations for ratoon are similar to those followed for plant crop. Because of the fast growth in early season, ratoon may require more irrigation as compared to plant crop. Twelve month crop may require nearly 115 acre inches of water (including rain). In dry seasons it may be irrigated with an interval of eight to ten days, and 13-15 day interval in the rest of the period, depending upon the rainfall and soil. At maturity limited irrigation will not lower the sucrose contents of cane. For the first two to two and a half months, six to seven inches of water per month will be sufficient. Then doses may be raised safely up to maturity. Liquid fertilizers are suitable for ratoon, but the Indian implements are not suitable for this purpose. Minor elements which sometimes play a major role in limiting the growth of the crop or in showing some abnormal symptoms may carefully be studied. Sometimes under less pronounced deficiency, the crop appears healthy, but such crop may respond well if the deficiencies are made good.

A properly cared ratoon will give at least 10-15 per cent more yield than that of the plant crop for two to three years, and will become like grape vine garden or Pan-mala (Betel vine garden) by its virtues. It should not be treated that it has lost its vigour and potential for high yields. Hawaiian research workers Bordon and Denison (1942) studied the growth rate, monthly elongation, length of stalk and many other aspects of ratoon and found that the ratoon has little more or the same vigour and potential as the plant crop has. Real profits lie in the ratoon and not in the plant crop. If growers and research workers make this " God's Gift " a successful pattern of cultivation, they will enjoy an all around improvement in cultivation of other crops too, by the higher profits through bumper ratoon yields. A good ratoon in Bombay State will yield 50-60 tons per acre depending upon the growth period. Hawaii, on an average harvests 94-95 tons of cane

and 10-11 tons of sugar per acre, while we harvest 13·5 tons of cane and 1·4 tons of sugar per acre. Will it be impossible for India, which is said to be the home of sugarcane, to increase cane yields through every sincere efforts?

REFERENCES

Amonymous (1957). Why Plough Out. *S. African Sugar Jour.*, **41**: 855-99.

Bordon, R. J. and Denison, F. C. (1942). Studies of optimum crop length. *Hawaiian Planters' Record*, **46**: 119-37.

Byrnside, D. S. and Sturgis, M. B. (1955, 1956, 1957). Fertilizers for sugarcane Reports of Projects. Department of Agronomy, L.S.U., Baton Rouge.

——— ——— (1958). Fertilizers for sugarcane. *Agricultural Ammonia*, **8**: 530-32.

Chou, J. C. (1957). Ratoon and Ratoon stunting disease control at Lungyen. *Taiwan Sugar*, **4**: **11**: 17-22.

Dillewijin, C. Van (1952). Botany of Sugarcane. Chronica Botanica, Waltham, Mass., U.S.A.

Dutoit, J. L. (1948). Annual summary of Agri. Data for Sugrcane Crop. 1955-56. *S. African Sugar Jour.*, **42**: 589-95.

Halliday, D. J. (1956). Manuring of Sugarcane, Centre D'Etude de L'Azote Geneva.

Kerr, H. W. (1958). Sugar Industry in Mauritius. *S. African Sugar Jour.*, **42**: 217-23.

Liu, K. C. (1958). Big Strides made in Taiwan Agriculture. *Taiwan Sugar*, **5**:**1**: 13-25.

Mertherne, R. J. and Herbert, L. P. (1957). Results of sugarcane varietal tests in Louisiana during 1956. *Sugar Bulletin*, **35**:**22**: 309-22.

Mohan Rao, N. V. G., Ram Rao, and Rao, E. J. (1956). Studies on sugarcane ratoons. *Proc. Int. Soc. Sug.cane Techn. 9th Congr.*: 233-54.

Stone, D. C. (1958). Some important jobs of Sugar Cane ratoon crop at its beginning. *Taiwan Sugar*, **5**:**5**: 22-25.

Stubbs, W. C. (1897). *Sugarcane*, **I**.

A PRELIMINARY NOTE ON THE EFFECT OF GIBBERELLIC ACID ON GROWTH AND TILLERING OF SUGARCANE

By

G. NARASIMHAM RAO, N. V. MOHAN RAO and P. HANUMANTHA RAO

(Sugarcane Research Station, Anakapalle, Andhra Pradesh)

GIBBERELLIC acid is a newly introduced hormone credited with high potentialities in promoting growth of plants. One of the important effects of applying this acid on plant growth is reported to be rapid elongation of the stem. It was reported from Hawaii (1956) that application of gibberellic acid to sugarcane increased the growth rate by 50 per cent.

Narasimham (1958) while reviewing the results of a large number of experiments conducted with varied species of crop plants that were treated with this new hormone, stated that gibberellic acid elongated the stalks most rapidly and that shoot elongation was mainly due to increase in cell volume rather than their increase in number. Gibberellic acid was also found to have effect on a number of plant characters and metabolic activities such as leaf growth, flowering, fruit set and breaking of dormancy of a number of cultivated plants.

Coleman (1958) reported that seed-piece treatment of sugarcane with gibberellic acid increased the height of plants by 56 per cent in a period of 23 days after which time the growth of treated plants ceased while that of control plants continued; Consequently there was no difference in height, of treated and un-treated plants, 112 days after treatment. He concluded from the results of field trials that gibberellic acid had little effect on length of millable cane and no effect on the final yield of millable cane, total solids, sucrose or purity of juice.

In order to study the effect of spraying gibberellic acid on the growth of sugarcane in its formative stage, a preliminary study has been conducted in pots at Sugarcane Research Station, Anakapalle in the current season and the results of the same are reported in this paper.

EXPERIMENTAL

Since only a small quantity of gibberellic acid could be obtained, the trials were laid out only in pots. The surface area of the pot is 1·66 sq. feet with 3′ depth of soil. Single budded setts of Co. 419 variety were planted on 23rd February, 1958. In order to obtain information on a possible interaction in the effect of gibberellic acid with the two major plant nutrients, nitrogen and phosphorus, these two factors were also included along with the hormone in varying proportions. The following are the details of the treatments.

1. Nitrogen 0, 50, 100 lb./acre in the form of ammonium sulphate.
2. P_2O_5—0, 75, 150 lb./acre in the form of single superphosphate.
3. Gibberellic acid—0, 25, 50 p.p.m. Ten ml. of aqueous solution for each pot were applied. This is equivalent to 0·25 mg. and 0·50 mg. of gibberellic acid per pot.

Nitrogen and P_2O_5 were applied to the soil in one dose on the 45th day after planting. Gibberellic acid was split into two halves; the first dose was given on the 45th day alongwith nitrogen and P_2O_5, while the second instalment was applied seven days later. Drops of aqueous solutions of gibberellic acid were put in between the leaf sheath and stalk. All the leaves in a shoot and all the plants in a pot received the gibberellic acid.

The trial was conducted on a factorial layout with 27 treatment combinations. One of the second order interactions (w. component) was confounded to reduce the size of the block from 27 pots to 9. Only one complete replication was harvested to record the effect of gibberellic acid on growth and tillering in the formative stage of the crop. The mean square with six degrees of freedom due to un-confounded $N \times P \times G$ interaction has been used as error in the test of significance made at one per cent level of probability.

Harvesting of the plants was done on the 140th day after planting or about 3½ months after initiating the treatments.

RESULTS

With a view to reduce the variation due to difference in age of the shoots, elongation of the shoot was recorded on the primary stalk only. The initial height of the shoot was measured from the surface of the soil to the first visible transverse mark on the top. The final height was measured on the day of harvest.

The difference, expressed as elongation of the stalk was statistically analysed and the effects are presented in Table I.

TABLE I

Elongation of main stalk (in inches)

Levels of nutrients	Levels of Gibberellic acid			Mean
	G_0	G_1	G_2	
N_0	10·5	18·4	20·1	16·3
N_1	11·6	14·9	16·7	14·4
N_2	13·4	17·2	15·0	15·2
Mean	11·8	16·8	17·3	
P_0	10·8	17·9	16·5	15·1
P_1	10·3	17·3	17·9	15·2
P_2	14·4	15·4	17·3	15·7
Mean	11·8	16·9	17·2	
	P_0	P_1	P_2	
N_0	15·1	16·7	17·2	16·3
N_1	14·0	14·4	14·8	14·4
N_2	16·1	14·4	15·1	15·2
Mean	15·1	15·2	15·7	

S.E.m (main effect) .. 0·533″
S.E.d (-do-) .. 0·754″
C.D. at 1 per cent (-do-) .. 2·80″
C.D. at 5 per cent (-do-) .. 1·85″
For values in the body of the table: S.E.m =0·924″; S.E.d =1·3077″; C.D. at 1 per cent =4·85″; C.D. at 5 per cent =3·20″

The effect of gibberellic acid in elongating the shoot was very highly significant. The differences due to nitrogen were not significant. P_2O_5 had no effect. An examination of the results in table above suggests an interaction of gibberellic acid with nitrogen. The beneficial effect of gibberellic acid appeared to be more pronounced in the absence of nitrogen. Actually the $N\times G$ interaction with four degrees of freedom was found to be significant at five per cent but not at one per cent level of probability. However, when it was separated into individual degrees of freedom the Nl Gl component which was estimated to be —2·02″ per pot was found to be significant, while the other three components did not reach significance. The relevant part of the analysis of variance is presented in Table II.

TABLE II

Analysis of variance $N\times G$ interaction

Due to	D.F.	Sum of squares	Mean Square	V_1/V_2	F. 1 per cent	F. 5 per cent
N ×G	4	55·88	13·97	5·46	9·15	4·53
Nl Gl	1	48·80	48·80	19·06	13·74	5·99
Nl G_q	1	0·32	0·32	..	..	..
N_q Gl	1	0·01	0·01	..	..	..
N_q G_q	1	6·75	6·75	2.64	..	..
Error	6	15·34	2·56	..	..	..

A PRELIMINARY NOTE ON THE EFFECT OF GIBBERELLIC ACID ON GROWTH AND TILLERING OF SUGARCANE

By

G. Narasimham Rao, N. V. Mohan Rao and P. Hanumantha Rao

(Sugarcane Research Station, Anakapalle, Andhra Pradesh)

GIBBERELLIC acid is a newly introduced hormone credited with high potentialities in promoting growth of plants. One of the important effects of applying this acid on plant growth is reported to be rapid elongation of the stem. It was reported from Hawaii (1956) that application of gibberellic acid to sugarcane increased the growth rate by 50 per cent.

Narasimham (1958) while reviewing the results of a large number of experiments conducted with varied species of crop plants that were treated with this new hormone, stated that gibberellic acid elongated the stalks most rapidly and that shoot elongation was mainly due to increase in cell volume rather than their increase in number. Gibberellic acid was also found to have effect on a number of plant characters and metabolic activities such as leaf growth, flowering, fruit set and breaking of dormancy of a number of cultivated plants.

Coleman (1958) reported that seed-piece treatment of sugarcane with gibberellic acid increased the height of plants by 56 per cent in a period of 23 days after which time the growth of treated plants ceased while that of control plants continued; Consequently there was no difference in height, of treated and un-treated plants, 112 days after treatment. He concluded from the results of field trials that gibberellic acid had little effect on length of millable cane and no effect on the final yield of millable cane, total solids, sucrose or purity of juice.

In order to study the effect of spraying gibberellic acid on the growth of sugarcane in its formative stage, a preliminary study has been conducted in pots at Sugarcane Research Station, Anakapalle in the current season and the results of the same are reported in this paper.

Experimental

Since only a small quantity of gibberellic acid could be obtained, the trials were laid out only in pots. The surface area of the pot is 1·66 sq. feet with 3′ depth of soil. Single budded setts of Co. 419 variety were planted on 23rd February, 1958. In order to obtain information on a possible interaction in the effect of gibberellic acid with the two major plant nutrients, nitrogen and phosphorus, these two factors were also included along with the hormone in varying proportions. The following are the details of the treatments.

1. Nitrogen 0, 50, 100 lb./acre in the form of ammonium sulphate.
2. P_2O_5—0, 75, 150 lb./acre in the form of single superphosphate.
3. Gibberellic acid—0, 25, 50 p.p.m. Ten ml. of aqueous solution for each pot were applied. This is equivalent to 0·25 mg. and 0·50 mg. of gibberellic acid per pot.

Nitrogen and P_2O_5 were applied to the soil in one dose on the 45th day after planting. Gibberellic acid was split into two halves; the first dose was given on the 45th day alongwith nitrogen and P_2O_5, while the second instalment was applied seven days later. Drops of aqueous solutions of gibberellic acid were put in between the leaf sheath and stalk. All the leaves in a shoot and all the plants in a pot received the gibberellic acid.

The trial was conducted on a factorial layout with 27 treatment combinations. One of the second order interactions (w. component) was confounded to reduce the size of the block from 27 pots to 9. Only one complete replication was harvested to record the effect of gibberellic acid on growth and tillering in the formative stage of the crop. The mean square with six degrees of freedom due to un-confounded $N \times P \times G$ interaction has been used as error in the test of significance made at one per cent level of probability.

Harvesting of the plants was done on the 140th day after planting or about 3½ months after initiating the treatments.

Results

With a view to reduce the variation due to difference in age of the shoots, elongation of the shoot was recorded on the primary stalk only. The initial height of the shoot was measured from the surface of the soil to the first visible transverse mark on the top. The final height was measured on the day of harvest.

The difference, expressed as elongation of the stalk was statistically analysed and the effects are presented in Table I.

TABLE I

Elongation of main stalk (in inches)

Levels of nutrients	Levels of Gibberellic acid			Mean
	G_0	G_1	G_2	
N_0	10·5	18·4	20·1	16·3
N_1	11·6	14·9	16·7	14·4
N_2	13·4	17·2	15·0	15·2
Mean	11·8	16·8	17·3	
P_0	10·8	17·9	16·5	15·1
P_1	10·3	17·3	17·9	15·2
P_2	14·4	15·4	17·3	15·7
Mean	11·8	16·9	17·2	
	P_0	P_1	P_2	
N_0	15·1	16·7	17·2	16·3
N_1	14·0	14·4	14·8	14·4
N_2	16·1	14·4	15·1	15·2
Mean	15·1	15·2	15·7	

S.E.m (main effect) .. 0·533″
S.E.d (-do-) .. 0·754″
C.D. at 1 per cent (-do-) .. 2·80″
C.D. at 5 per cent (-do-) .. 1·85″
For values in the body of the table
- S.E.m =0·924″
- S.E.d =1·3077″
- C.D. at 1 per cent =4·85″
- C.D. at 5 per cent =3·20″

The effect of gibberellic acid in elongating the shoot was very highly significant. The differences due to nitrogen were not significant. P_2O_5 had no effect. An examination of the results in table above suggests an interaction of gibberellic acid with nitrogen. The beneficial effect of gibberellic acid appeared to be more pronounced in the absence of nitrogen. Actually the N×G interaction with four degrees of freedom was found to be significant at five per cent but not at one per cent level of probability. However, when it was separated into individual degrees of freedom the Nl Gl component which was estimated to be —2·02″ per pot was found to be significant, while the other three components did not reach significance. The relevant part of the analysis of variance is presented in Table II.

TABLE II

Analysis of variance N×G interaction

Due to	D.F.	Sum of squares	Mean Square	V_1/V_2	F. 1 per cent	F. 5 per cent
N×G	4	55·88	13·97	5·46	9·15	4·53
Nl Gl	1	48·80	48·80	19·06	13·74	5·99
Nl G_q	1	0·32	0·32	..	..	..
N_q Gl	1	0·01	0·01	..	..	..
N_q G_q	1	6·75	6·75	2.64	..	..
Error	6	15·34	2·56	..	..	..

The results thus indicated that the influence of gibberellic acid progressively diminished as the level of nitrogenous fertilizer increased.

Since the Gibberellic acid was applied to every shoot in a pot its overall effect on the elongation of the stems is sought to find out by recording the total length of cane formed shoots which is akin to the length of millable cane at harvest. The results are presented in Table III.

TABLE III

Mean length of cane from all the shoots in a pot (in inches)

Factor	Level of factor		
	0.	1.	2.
Nitrogen	42·1	74·5	87·7
Phosphorus	65·5	68·0	71·0
Gibberellic acid	61·5	73·8	69·0

S.E.m = 4·43″
C.D. (P=0·01) .. 23·26″
C.D. P=0·05 =15·33″

The data disclosed that except the main effect of nitrogen, none of the other main effects or interactions were found to be significant. It is thus evident that while the gibberellic acid has significantly increased the elongation of the stem, the total length of shoots from a single pot did not show any effect. This is apparently due to the action of gibberellic acid on the production of tillers. While nitrogen increased the number of shoots, gibberellic acid does not seem to have beneficially influenced this important function viz., tillering to any appreciable extent. The production of tillers as measured by the difference between the number of plants at the time of initiating the treatments and those at harvest is presented in Table IV.

TABLE IV

Number of shoots produced per pot

	G_0			G_1			G_2			Mean for N
	P_0	P_1	P_2	P_0	P_1	P_2	P_0	P_1	P_2	
N_0	1	1	1	0	0	2	0	0	1	0·66
N_1	6	0	5	1	1	0	2	0	4	2·11
N_2	8	4	10	7	6	5	0	4	3	5·22
Mean for Gibberellic acid ..		4·00			2·44			1·55		
Mean for P_2O_5 ..		2·78			1·78			3·44		

The figures furnished in the above table clearly indicated that nitrogen increased the production of shoots while the effect of phosphoric acid seemed to be erratic. Gibberellic acid seemed to depress the tillering.

Since the total numbers of shoots per pot recorded at the time of initiating the treatments did not statistically differ, the data of total number of shoots found at harvest was statistically analysed and the results are presented in Table V.

TABLE V

Mean number of shoots per pot at harvest

	G_0	G_1	G_2	Mean
N_0	6·3	7·6	5·6	6·5
N_1	10·3	6·3	7·6	8·1
N_2	17·0	9·3	8·3	11·9
Mean	11·2	7·7	7·2	..

S.E.m (main effect) .. .. .. 0·60
C.D. (P=0·01) .. .. .. 3·16 per pot
C.D. P_{005}=2·08
S.E. of a single value in the body of the table 1·04 ,,
C.D. -do- (P=0·01) 5·45 ,,
C.D. -do- (P=0·05) 3·61 ,,

The total number of shoots was increased with an increase in the level of nitrogen while gibberellic acid was observed to have had a progressively retarding effect on the same. Both the effects were found to be significant at one per cent level. The linear effect of gibberellic acid was highly significant while the quadratic component did not reach significance. Phosphoric acid did not exert any significant effect on shoot number. Neither the average effect of N×G interaction nor any one single component among the four degrees of freedom reached significance.

Elongation of the stalks by the gibberellic acid seemed to be at the expense of the production of tillers. This is similar to the well known phenomenon of rapidly growing cane varieties in the early stages having poor tillering at the end. Apparently due to this the total dry-matter produced from a unit area did not vary due to the application of this hormone. The results are presented in Table VI.

TABLE VI

Mean dry matter produced from a single pot (in gms.)

Factor	Level		
	0	1	2
Nitrogen	165·0	254·7	319·1
P_2O_5	231·1	250·4	256·4
Gibberellic acid	251·2	246·7	242·1

It is thus seen from Table VI that increase in dry matter is approximately proportional to the increased application of nitrogen. This is mainly due to the production of more shoots than the elongation of the stalk, the differences in the latter being not significant as reported in Table I. The differences due to gibberellic acid and phosphorus are negligible.

SUMMARY

A preliminary study to find out the effect of applying gibberellic acid to the young sugarcane plants was conducted in pots with variety Co. 419. The two major plant nutrients (viz.) nitrogen and P_2O_5 were also applied in varying levels along with the hormone to note their interaction if any.

Gibberellic acid was found to exert a significant effect on the elongation of the stem and the increase recorded three and a half months after applying the hormone amounted to 55 per cent over control. But it was observed that the elongation of the stalk by the gibberellic acid was at the expense of tiller production which was significantly depressed; Consequently, there was practically no improvement in the total dry-matter produced by the application of this hormone. The elongation of stalk by gibberellic acid was higher when nitrogen was not added and progressively decreased as the level of nitrogen increased.

While nitrogen increased tillering significantly, phosphoric acid did not exert any significant effect on either elongation or tillering in these studies.

ACKNOWLEDGMENT

The work has been carried out under the Sugarcane Research Scheme, which is partly financed by the Indian Central Sugarcane Committee to whom our thanks are due. Our thanks are also due to Messrs. Plant Protection Limited, for their kind supply of Gibberellic acid.

REFERENCES

Coleman, R. E. (1958). The effect of gibberellic acid on growth of sugarcane. *Sugar Journal*, 23-26, April.
H.S.P.A. (1956). Experiment Station Committee Report., 11-12.
Narasimham, B. (1958). Gibberellic acid—A new growth chemical. *Andhra Agricultural Journ.*, 5(1): 27-35.

SUGARCANE INDUSTRY IN BOBBILI ZONE (Andhra Pradesh)

By

E. JAGANNADHARAO

(Sugarcane Liaison Farm, Bobbili, Andhra Pradesh)

INTRODUCTION

SUGARCANE is the most important commercial crop in the taluks of Bobbili, Parvatipuram, Salur and Palakonda of this development zone, commanding an area of over 16,000 acres. Of this, the area under sugarcane in Bobbili and Parvatipuram taluks is mostly drawn by the sugar factories of Bobbili, Seethanagaram and Rayaghada (Orissa), while cane from 50 per cent of the area in Salur and the entire area in Palakonda taluks is utilized for jaggery manufacture. Sugarcane cultivation has increased by leaps and bounds and from a mere thousand acres in 1932 in Bobbili taluk it has gone up to 14,500 acres in 1953-54. This phenomenal increase has been due to sugar factories constructed at Bobbili and Seethanagaram in the years 1934 and 1940 respectively. Thus the small area of 1,000 acres of the pre-1930 that was confined to areas of assured water supply has now spread over areas of indifferent water supply and even to dry lands. It is due to the drought resistant Coimbatore hybrid canes and the policy of payment of sugarcane on cane weight basis. This un-natural development has led to poor harvests of 10 to 15 tons per acre which is 40 to 50 per cent below the state average for cane yields. In this paper an attempt has been made to indicate the importance of sugarcane in the Agricultural economy of the ryot in this zone and the need for a bold approach to develop this under-developed area.

PLACE OF SUGARCANE IN THE AGRICULTURAL ECONOMY OF THE RYOT IN THE ZONE

Sugarcane is the most important commercial crop in the taluks of Bobbili, Parvatipuram and Palakonda while it comes only next to Gogu (Hibiscus Spp.) in Salur taluk. The relative importance of the crop is indicated in Table I below:—

TABLE I

Sl. No.	Particulars	Bobbili	Parvatipuram	Palakonda	Salur
1.	Area under Sugarcane: in the past 3 seasons (acres)				
	a 1954-55	12,300	2,000	3,204	2,203
	b 1955-56	13,088	1,825	2,137	2,275
	c 1956-57	9,900	1,825	2,200	2,200
2.	a. Total cropped area in the taluk	1,39,518	85,000	1,36,637	1,35,200
	b. Per cent of total sugarcane area to total cropped area	9-38	2-15	1-50	1-39
3.	a. Total area under commercial crops	41,363	11,355	21,531	11,931
	b. Per cent area under sugarcane to total area under commercial crops..	31	16.07	9.8	12.2
4.	Production of sugarcane during 1956-57 (tons) ..	1,48,500	29,200	52,000	32,000
5.	Average, yield of sugarcane per acre (tons)	15	16	25	15
6.	Quantity consumed by sugar factories at Bobbili and Rayaghada (tons)	90,000	20,000	Nil	15,000
7.	Value of sugarcane produced at Rs. 39/- per ton of cane (Rs.)	57,91,500	11,38,500	20,28,000	2,44,800
8.	Other important commercial crops and their areas in acres				
	GOGU	9,905	6,150	15,537	8,360
	GROUND NUT	15,290	2,206	3,285	9,571
	GINGELLY	3,080	..	362	..
	TOBACCO	..	780	160	..

SEASONAL CONDITIONS

This tract is characterised by severe summers with day temperatures ranging between 103°F. and 113°F. from April to early in June. Cold and dry weather prevails from mid-November till the end of

January and winter is also very severe with temperatures ranging from 53° F. The average annual rainfall ranges from 45″ to 59″ in the various taluks and the season-wise details of rainfall are furnished in Table II.

TABLE II

Average rainfall in inches

Name of taluk	Hot Weather		S. W. Monsoon		N. E. Monsoon		Total
	Rains	No. of rainy days	Rains	No. of rainy days	Rains	No. of rainy days	
Bobbili	7·19	13	23·60	43	12·43	16	45·3
Parvatipuram	7·85	13	34·93	57	7·73	11	50·5
Salur	9·70	..	33·39	..	11·73	..	54·8
Palakonda	3·01	6	45·30	55	10·96	13	59·3

2. Rains are received in both the monsoons but the South-west monsoon is more active. A few good showers are received in the summer months of April-May. The north-east monsoon is characterised by high gales affecting grown up cane crops. The south-west monsoon brings in freshes to the rainfed tanks.

SOILS

Sugarcane was confined to tank ayacuts which are mostly clayey loams to loams, but now, with extended cultivation and taking advantage of the newer drought resistant canes, it is also being grown in uplands without any source of irrigation and these soils are mostly sandy loams. The latter method of cultivation is mostly confined to a few pockets in the Sithanagaram factory area of Bobbili taluk. The soils in tank ayacuts are fairly retentive of soil moisture and sugarcane crops have been found to survive with hardly any irrigation in February-March, subsequently depending upon the uncertain summer showers of April-May and entering the active monsoon period.

SUGARCANE AND ITS CULTURE

With the fillip given for the extension of sugarcane area by the opening of two sugar factories in the taluk the sugarcane area rapidly increased from about a thousand acres in 1934 to over 14,000 acres in Bobbili taluk alone while the areas in Parvatipuram and Salur taluks also increased to about 2,000 acres in place of almost negligible areas prior to 1930. This increase in area under sugarcane has mostly been in areas of un-assured water supply and consequently the grower is treating sugarcane in this zone as a semi-dry crop and reaping whatever he is able to get depending upon seasonal conditions.

The lands intended for sugarcane which are invariably grown to paddy, are brought to fine tilth immediately following paddy harvest and sugarcane is planted in plough furrows 2′ to 2½′ apart, water is let in and three budded setts at 15,000 per acre are pressed in. Planting is done between January and March with the bulk of the area being planted in the middle of February. About 20 per cent of the area is also planted in May if good summer showers are received. As facilities for further irrigations are not available the sugarcane fields are flood irrigated immediately following planting and when the field comes to condition, it is worked in the inter-spaces with a country plough. This is to conserve moisture in the months of March-April-May and another ploughing is given if a shower is received in April or May. This method of soil conservation is spreading to the entire sugarcane aıea to the detriment of germination and subsequent stand of the crop. The germination in such fields is affected by the soil covering the freshly planted setts to a depth of 6″ and also by trampling of the animals at work. Germination counts revealed hardly 35 to 40 per cent germination in these fields.

The young shoots lie exposed to severe hot weather period in April-May without any certainty of irrigation and during this period, the early shoot borer incidence s at its peak. Incidence upto 50 per cent is very common, and due to repeated attack of the tillers that emerge, the cane crop planted in the month of February-March will hardly have any canes with internode formation in June. Only with the receipt of good rains in June-July, the crop revives, puts forth fresh tillers and grows. Thus the crop finally harvested will contain over 80 per cent of tillers that have emerged in May—June and this partly accounts for low sugar recovery in factories.

The only other operations for the crop are earthing up alternate rows in August and wrapping in September; clamping cane clumps is resorted to only if there is some growth.

Manuring is done by the liberal use of artificials like Ammonium sulphate. This practice has increased within the last five to seven years. It is applied to give upto 100 lbs. Nitrogen per acre in two to three doses beginning from July. The final dose is given even late in September as ryots feel that such split and late applications put up cane yields. This is another potent contributory factor for the declining recoveries in the factory.

Thus, lack of irrigation facilities and exposing the young sugarcane crop in its formative stage to almost wilting condition, taking easy the wide-spread incidence of early shoot borer, that systematically kills almost all the tillers emerging upto May, and late and indiscriminate manuring with fertilizers have all contributed to the low acre yields of cane and low recoveries in the sugar factories. The average sugarcane yield in each of the taluks of the zone and the sugar recovery per cent in the sugar factories are furnished in Tables III and IV.

TABLE III

Average yield of sugarcane

Name of taluk	Yield in tons per acre	Remarks
Bobbili	15	Semi dry area
Salur	15	Semi dry area
Parvatipuram	16	Semi dry area
Palakonda	25	Irrigated area

TABLE IV

Average sugar recovery in the factories

Year	Sri Rama Sugars and Industries Ltd.	
	Seethanagaram Factory	Bobbili Factory
1950–51	10·65	10·19
1951–52	10·24	8·97
1952–53	10·73	9·47
1953–54	9·81	9·43
1954–55	9·01	9·10
1955–56	7·80	8·94
1956–57	9·11	9·63

SECOND PLAN AND ITS OBJECTIVES WITH REFERENCE TO CANE DEVELOPMENT IN THIS ZONE

Sugarcane Development scheme was extended to this zone as part of the second five year plan by the opening of Sugarcane Liaison Farm, at Bobbili and starting of intensive Sugarcane Development work in the taluks of Bobbili, Parvatipuram, Salur and Palakonda. The object of the extension scheme is to increase sugarcane yield in the zone by 20 per cent per acre by 1960-61. Work was started in January, 1957. The increase in acre yield of sugarcane is sought to be achieved by the introduction of cultural, Manurial and varietal improvements.

Zonal Farm

The Sugarcane Liaison Farm at Bobbili was started in January, 1957, on 20 acres of wet land placed at the disposal of the Government by the management of Sri Rama Sugars and Industries Ltd., Bobbili. The working expenses of the Liaison Farm are to be met by the Factory authorities while the charges on Technical staff comprising of a Superintendent, two Sugarcane assistants and two fieldmen will be borne by the State Government and the Indian Central Sugarcane Committee. The results of proven researches at Sugarcane Research Station at Anakapalle that are to be put across in the extension side are further tested on the farm here for their suitability to the zone, besides laying out experiments and gathering data on the problems purely of local importance.

The following recommendations from the Sugarcane Research Station, Anakapalli are under demonstration on the Sugarcane Liaison Farm, here and the observations so far made are also tabulated.

Local method	Suggested improvement under Demonstration at the S.L.F. Bobbili	Indications so far available on the suitability of the recommendation
1	2	3
1.a. Cultural: Repeated ploughing and planting sugarcane in shallow plough furrows spaced 2 to 2½ apart. Ploughing between cane rows ten to 12 days after planting and covering the furrows to conserve soil moisture.	Planting in deep trenches 40″ apart with 16″ width of furrows and 8″ depth. A 4″ loose soil bed to be Provided at the base of furrows. OR Plough deep and form ridges and furrows as above. Hoeing in the furrows after each irrigation or rainfall to conserve soil moisture.	1. Deep trench planting and hoeing in furrows ensured even germination and it was 75 per cent against 35 per cent to 40 per cent recorded under neighbourhood. 2. Early shoot borer incidence was 4 per cent in deep trenches as against 9 per cent in shallow trenches. 3. Population at earthing up was 54,000 in this method as against 31,000 in the adjoining holding of ryots.
B. Earthing in August: Light earthing up to 4″ given for every alternate row of cane.	High earthing up by keeping the furrows depth between the rows of cane at 6 to 8″.	High earthing up prevented lodging inspite of 25″ rain received in August-September. Under local method about 30 per cent cane clumps lodged and clamping had to be resorted to immediately.
C. Wrapping is done twice in August-September and clamping of cane done when crop height is 4 to 5″ of millable cane.	No. wrapping is done thus saving Rs. 25/- on two wrappings and Rs. 15/- on clamping Trash twist propping done in September, the cost of operations being Rs. 20/- per acre.	The utility of trash twist has to be tested during the N.E. Monsoon. At present there is a saving of Rs. 15/- per acre on the operation.
D. Insecticidal control: No. control measures are adopted. Borer incidence was recorded upto 50 per cent.	Spraying with 0·32 per cent D.D.T. or 0·02 per cent Endrin was done thrise when the crop (Planted early in March, 1957 was 4, 6 and 9 weeks old).	In the demonstration plots dead hearts were 6 per cent in unsprayed plots as against 14·5 per cent in sprayed plots. Similar observations from the ryot holdings are as follow (for the average of 18 demonstration plots). Unsprayed. 33·5 per cent sprayed. 11·9 per cent The crop in sprayed plots is uniform in growth, with an average crop height of 110 inches for sprayed and 88″ for unsprayed in Co.419 in September.
2. MANURIAL: No basal dressing of bulky organic manuring done. Fertilizers to give from 75 lb. N. to 100 lb. N. as ammonium sulphate given in two to three doses from July to September.	Application of 100 lb. Nitrogen in one dose in June-July advocated press mud at 10 tons per acre applied before planting in furrows. Spraying urea to give 25 lb. N. per acre in April, demonstrated. This was applied following a sharp shower and 50 lb. N. applied to soil in July.	Spraying Urea in April appeared to induce better crop growth and vigour than plots receiving all 100 lb. N. in July. Results to be confirmed at harvest.
3. VARIETAL: Co. 421 is most popular as a mid cane, Co. 527 as an early cane and Co. 419 as a late cane. Co. 449 is spreading now.	Varieties Co. 419; Co. 449; Co. 421; Co. 527; Co. 650; Co. 957 and Co. 997 are under observation.	Co. 449 has done very well as a good drought resistant variety so far followed by Co. 957, Co. 421 Co. 650. Co. 419 badly suffered due to severe drought this year (rainfall in May was 0·35 inches and no facilities for irrigation. Drought resistance and resistance to early shoot borer were found to follow a similar trend. Variety Co. 449 that resisted drought well, also recorded low borer incidence. The percentage of incidence was 10·5 per cent as against 48 per cent in Co. 419 and between 25 per cent to 40 per cent in other varieties.

From the indications recorded on the zonal farm so far, it was found that suitable improvements on these lines can be extended in the entire zone.

Extension Work

The limiting factor in improving acre yields has been due to lack of irrigation facilities. Rainfed tanks are of poor storage capacity consequent on silting up of the tank beds and lack of any major repairs to them. The underground water supply at reasonable depths of 20′ to 25′ has been very scanty and hence large scale well digging has not been resorted to, as the ryots are unable to afford the investment on deep wells. Deep trial bores with power rigs have to be taken up to explore the possibility for tapping the subterranean supplies. However sustained propaganda for digging of wells is being done, as even these small wells will go a long way increasing irrigation consciousness in the ryots.

Possibility of storing the seasonal flood waters in the rivers Vegavathi, Swaranamukhi and Nagavali has already been explored and the following irrigation projects are already in progress which are expected to benefit about 6,800 acres of sugarcane. The particulars of these are furnished below:—

Sl. No.	Name of the project	Name of the river	Taluk to be benefited	Approximate area under sugarcane to be benefited (acres)
1.	Nagavali Right bank canal.	Nagavali	Parvatipuram	300
	Narayanapuram dam	,,	Palakonda	2,500
2.	Karivalasa project	Vegavathi	Salur taluk	1,000
3.	Venkatabhairepuram Project	Swarnamukhi	Bobbili	3,000

Rainfed tanks, were originally meant for supplementing the rain water to the paddy fields and were not intended to hold water for long duration crops like sugarcane which are to pass through a dry period from January to June. Hence in other districts like Chittoor and Anantapur, where also sugarcane is cultivated in tank ayacuts, these ayacuts are studded with masonry wells which supplement the tank irrigation from February-March onwards when the tanks get exhausted. But in this zone, wells in tank ayacuts are few and far between thus exposing the young sugarcane crop to the mercy of uncertain summer shower. Few wells seen here and there are of low depth and diameter capable of yielding poor supplies even for a *picottah*. Ryots have not got the experience of digging deeper and wider wells which will be capable of yielding better supplies. Wells of at least 30′ to 35′ depth must be encouraged and these cost upto Rs. 1,600/- per well. A scheme for subsidsing wells digging must be initiated with government subsidy of at least 50 per cent of the total cost. 500 wells in Bobbili taluk, and 250 each in the other two taluks of Salur, and Parvatipuram can be sunk in the tank ayacuts, which will ensure proper summer irrigation to at least 3,750 acres of sugarcane area.

Superficial boring upto 100′ have been tried with hand boring sets in some places of these taluks and they have not yielded satisfactory results. Deep bore upto 500′ or more with power drills should be taken up and as cane growers of the area are mostly poor, the state should put up trial bores in representative areas where big blocks of sugarcane can be irrigated. Each bore well if taken to a depth of 500′ is said to cost about Rs. 10,000/- and even with a minimum discharge of 200 gallons per minute it will be able to irrigate a block of eight to ten acres of sugarcane at 10 to 12 day intervals. A successful bore well is struck with a power drill at a depth of about 250′ near Amadalavalasa in this district, thus showing the possibilities of deep bore wells in the area; successful bore wells can be entrusted to multipurpose Co-operative societies by forming these in such villages and water can be sold to the beneficiaries.

Thus tapping of subterranean water resources by masonry wells and bore wells is the only means of assuring adequate number of irrigations between March and June, the cane yield in the tract can be improved by at least 50 per cent of the present 15 tons average per acre.

Even under the limitations obtaining at present, the extension of development work has been started in right earnest during the year. The following are some of the items that have already attracted the cane growers:—

Plant Protection: Growers were convinced about the efficacy of early shoot borer control by spraying D.D.T. or Endrin and 124 demonstration plots were laid. Besides this, an area of 212 acres were sprayed at least twice in the taluks. The average incidence as recorded from 18 plots indicated 33·5 per cent in untreated plots as against 11·9 per cent in treated plots. It is likely to spread to larger areas in the coming seasons.

Manuring at the optimum dose of 100 lb. Nitrogen was widely popularised and an area of 13,000 acres was covered thus during the current season. The full benefits of good manuring are not being realised by growers, as sugarcane crop suffers a severe setback in summer months.

Propping cane with the simple trash-twists is being demonstrated and for the current season, a target of 1,450 acres is fixed. Due to an intensive drive given for this operation, the response in the new development taluks has been good and already over 750 acres have been covered.

Thus by plant protection, proper manuring and by securing the crop against lodging, which have already been successfully demonstrated, the cane grower will be able to improve his cane yields by at least ten per cent. Efforts are being made to widely popularise these and other improvements with a view to achieve the targeted improvement of 20 per cent increase in yield at the end of the second plant period.

Summary and Conclusion

Sugarcane is a very important commercial crop in the Bobbili zone and under the sugarcane development scheme it is covered by the Sugarcane Liaison Farm, Bobbili. The acre yield of sugarcane per acre is about 15 tons. Inspite of the soil being quite suitable for cane cultivation, the limiting factor being irrigation in the formative stage of the crop from March to June. An attempt has been made in this paper to indicate the present position of sugarcane cultivation and possibilities of its future development. The need for exploring the subterranean water supplies by State sponsered bore wells and well subsidy schemes are indicated. The work done at the Sugarcane Liaison Farm, even in its very first year of starting and extension work in progress in the zone are briefly indicated.

EXPERIMENTS FOR INCREASING THE GERMINATION PERCENTAGE OF SUGARCANE*

By

K. L. Mukherjee

(Banaras Hindu University, Varanasi-5)

Introduction

THERE can be no two opinions regarding the benefits of selecting good quality sugarcane setts whose buds have better germination capacity at the time of sowing. This does not only save considerably the expenditure in the use of excess planting material but ensures a uniform stand of the crop in the field. Sugarcane buds are expected to germinate immediately if placed under proper environmental conditions (Mukherjee and Mukherjee, 1959). Deterioration in the germination percentage of these buds may be due to genetic or physiological factors or is caused by the mishandling of the seed canes. This attempt is the outcome of the requests from the local (Deoria) farmers to suggest some effective means for improving the poor germination of the planted canes in these areas. But due to restricted facilities the work lacks, at places, proper order of scientific approach. A complete review of the work of similar nature by foreign authors is available in Dillewijn's book (1952). Nevertheless mention may be made of the important contributions of Indian workers in this line.

Rege and Wagle (1934) were the early Indian Workers who reported the variations in the germination behaviour of sugarcane buds obtained from different portions of the stem. Iyenger (1951), and Choudhri and Bhatnagar (1953) have given fresh interpretations to such observations. Variations in age, food, nutrient, water and hormonal contents have been forwarded as explanations by many of these workers. Pre-sowing treatments to sugarcane setts with water i.e. soaking (Khanna, 1933, 1935), lime (Khanna, 1933), nutrients (Khanna, 1933; Rege and Wagle, 1934), solutions with different H-ion concentrations (Singh *et al.*, 1935), growth regulating substances (Choudhri and Bhatnagar, 1953) and various physical stimuli (Sharma, 1944), and also other aspects regarding germination of sugarcane setts (Dutt *et al.*, 1938; Rao, 1937) have been carried on extensively in India. Some of these treatments are found to be very effective in increasing the germination percentage of the buds. The causes may be attributed to the greater availability of food, water or nutrients from the substrata to the growing bud or an internal metabolic change in the sown setts culminating to a favourable influence on the emergence and after growth of the sugarcane buds.

Experimentation

Sugarcane stalks (Co. 419), obtained from a local farmer, were cut into single-budded setts. These were planted, with or without a pre-treatment, in different rows under field conditions. Each row contained fifty setts and represented the individual series designed for each set of experiment.

Experiment I: To observe the influence of the position of sugarcane buds on stalk on their germination percentage:

Nodes with buds from different portions of the stems were cut and sown in different rows. Two buds from each of the regions—the top-most, the middle and the basal—were selected from each stalk for experimentation.

Experiment II: Effect of hot-water-bath treatment to the pre-germinating sugarcane buds on their germination percentage:

Setts were sown after dipping in hot water (35°, 45° and 55°C) for a period of ten minutes. The control was kept at 25°C.

Experiment III: Effect of partial desiccation on the germination percentage of sugarcane buds:

The setts were allowed to desiccate in sun for two hours (11 A.M. to 1 P.M.) and sown (III-c) in contrast to those dipped in water (III-b) or kept under shade (III-a) for the same period. The rows were watered in the next morning.

* Abstract published in Proc. Ind. Sci. Congr. 45: p. 446, 1958.

EXPERIMENT IV: Effect of various pre-sowing treatments on the germination percentage of sugarcane buds: This included the following treatments prior to sowing:—

(a) Setts sown without any treatment (control).
(b) Setts dipped in well water for 24 hours.
(c) Ends of cut setts dipped in powdered quick lime.
(d) Setts dipped in lime water for ten minutes.
(e) Setts dipped in one per cent HCl for ten minutes.
(f) Setts dipped in Knop's nutrient solution for 24 hours.
(g) Setts dipped in saturated Dextrose (commerical grape sugar) for 24 hours.
(h) Setts dipped in saturated sucrose solution for 24 hours.
(i) Setts dipped in saturated ∝-D glucose (pure) solution for 24 hours.
(j) Similar as (i) followed by dipping in nutrient solution for one hour.

TABLE I

Germination percentage of sugarcane buds in relation to their position on the stalks and various pre-sowing treatments

Experiment	Treatment series	Date of observation* (per cent)	
		27-3-57 (30th Day)	11-4-57 (45th. Day)
I	*Influence of position of buds*		
	(a) Top	50	70
	(b) Middle	30	100
	(c) Bottom	40	70
II	*Hot-water-bath-treatment*		
	(a) 25°C	70	80
	(b) 35°C	70	100
	(c) 45°C	80	90
	(d) 55°C	90	80
III	*Natural desiccation*		
	(a) Control	30	50
	(b) Water-dipped	70	80
	(c) Sun dried (partial desiccation) ..	20	80
IV	*Pre-sowing treatments*		
	(a) Control	30	60
	(b) Well water dipped	70	80
	(c) Lime powder dipped	60	50
	(d) Lime water dipped	50	80
	(e) 1 per cent HCl dipped ..	40	70
	(f) Nutrient solution dipped ..	40	80
	(g) Dextrose (commercial) solution dipped	40	70
	(h) Sucrose solution dipped.. ..	40	60
	(i) ∝-D glucose (pure) solution dipped	40	50
	(j) Same as (i) Nutrient solution dipped	60	70

Date of sowing: 25-2-57
*Observations were taken on the 30th. and 45th. days from the date of sowing.

Buds from the middle portion of the stem were used in all the experiments except Expt. I. Observations for the number of buds germinated were made after 30 and 45 days respectively from the date of sowing (25-2-1957). The author thinks that very few fresh germinations occur after a period of a month and a half. The results in terms of 'per cent germination' have been shown in Table I and Fig. 1.

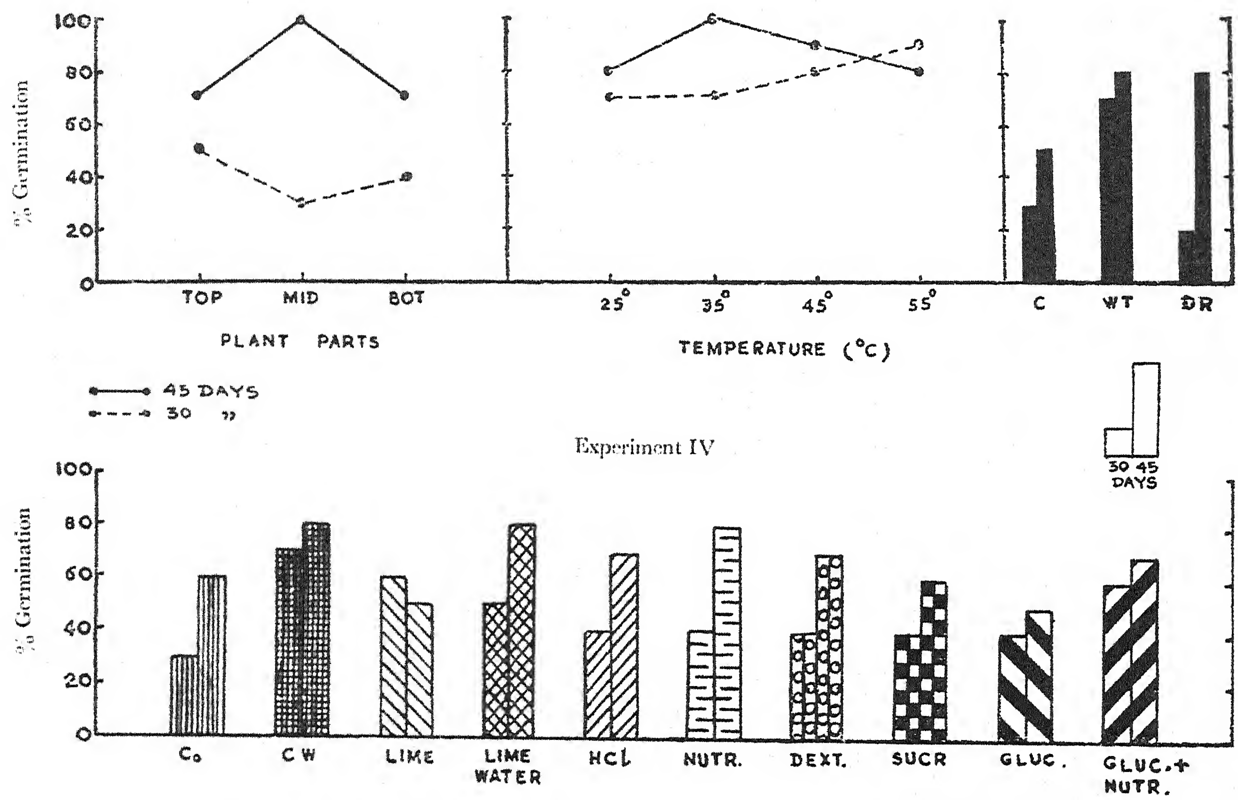


FIG. 1. Trials for improving the germination percentage of sugarcane at Deoria (U.P.)

Experimental Findings and Discussion

Experiment I shows the initial and final germination percentages of sugarcane buds in relation to their position on the stalk after 30 and 45 days respectively. The buds taken from the top germinated earlier as compared to middle and lower buds. Similar observations have been made by Rege and Wagle (1934) and Iyengar (1951) also. This early germination prevents the inroads of many pest attacks (Rege and Wagle, 1934). The middle buds, on the other hand, germinate comparatively at a slow pace but its final germination percentage is the highest. Buds from the basal nodes give more or less similar results as the apical ones within this time limit but starts late in emergence. This has not wholly confirmed the findings of Clements (1940).

The reasons for the germination gradient corresponding to the influence of position or age of sugarcane buds on the stalk can be sought in some of the earlier observations (Dillewijn, 1952). The early germination in case of the upper buds is caused by its juvenility and rich substrata of food and water—specially glucose and major mineral nutrients, but not by sucrose (Clements, 1940; Lal and Mukherjee, 1958; Mukherjee, 1956). The failure, on the other hand, of a number of tender buds to germinate in the final stage, which considerably decreases the final germination percentage, is possibly due to the presence of growth inhibiting-substances causing 'apical dominance' or failure of giving out roots in case of those buds. The final germination is no doubt best in the middle buds and this probably is related to higher contents of growth promoting substances and better emergence of roots and better food reserve. The lower buds, on the contrary, are poorest in their readily available food reserve (glucose), and in many cases are injured by insect or pest attacks or by mechanical means (Clements, 1940). In spite of these handicaps the lower buds possess superior rooting

capacity which probably gives them better stand at the stage of a month and a half. Thus the effect of the age of seed pieces is one of the striking internal factors affecting the germination of sugarcane. With the aging of the sugarcane tissues much the mobile and easily available sugar (glucose) is converted to reserve sugar (sucrose) which needs to be first converted to the former before being utilized by the growing bud. Hence the upper buds are at an advantage for an early germination.

Experiment II shows the influence of hot-water-bath-treatment on the germination behaviour of sugarcane buds. It has been clearly marked that higher temperatures initiate an early emergence of growth from the sugarcane buds, but this is not proportionately maintained till the final germination stage and temperature higher than 35° C possibly injures the bud which is eventually revealed by a sharp decrease in the germination percentage. According to the findings of this experiment it appears that a temperature treatment of 35° C is helpful in bringing higher germination of the buds. This is in corroboration with many earlier works (Brandes and Klaphaak, 1923; Dillewijn, 1952) and can possibly be due to a greater hydrolysis of sucrose by activating the enzymatic action of sucrose or invertase. A further improvement in the 'hot-water-dip' treatment can be brought by employing one per cent $Ca(NO_3)_2$ solution (30°-35° C) and soaking for 24 to 48 hours (Clements, 1940).

Experiment III shows the effects of partial desiccation (sun drying) on the germination of sugarcane buds. Water-dipped buds emerge early and maintain its high level of germination upto the final stage. Khanna (1933) has also stated a higher germination percentage, more vigorous growth, greater number of tillers per plant and heavier crop at harvest time due to water-soaking treatment. In case of partial desiccation, germination percentage at the early stage, although not very encouraging, was definitely higher than the untreated ones at one and a half month stage. Beneficial influence of water-dipping may be attributed to the essential character of water for the germinating bud which after being absorbed eventually brings many favourable chemical changes conducive to quicker and better germination, more important being the conversion of carbohydrates to reducing sugars (Bonner, 1950). Partial desiccation does not injure the bud, on the contrary, appears to favour the hydrolysis of sucrose (Curtis and Clark, 1950) and ultimately brings better germination response.

Experiment IV shows the effect of well water soaking, acid treatment and extraneous supply of mineral nutrients and sugars on the germination behaviour of sugarcane buds. Obviously, soaking in well water (IV-b), treatment with lime water (IV-d) and supply of nutrients (IV-f) eventually gave good results. No appreciable improvement could be brought about by acid treatment (IV-e), supply of sugars (IV-g, h) or supplementing inorganic nutrients after treating with hexose sugar (IV-j). Treatments with crude lime (IV-c) or dipping in saturated α-D glucose solution were found to be either ineffective or even deleterious.

The well water of this locality contain a considerable amount of calcium and also many other soil leached inorganic nutrients essential for the plant growth. The beneficial effects of calcium and extra nutrient supply is proved by the treatments IV-d and f respectively. Khanna (1933) has also stated the increased germination percentage and higher yield due to lime saturated solution treatment. According to Rege and Wagle (1934), supply of sulphate of ammonia at the time of planting helps to hasten germination and leads to higher success in getting better yield and this is more so in case of bottom setts. The unpublished data of the author (1956) have shown that water, reducing sugars and mineral nutrients are the first few essential internal requirements of a sugarcane bud in the process of germination. The element calcium is essential for the development of new tissues and favours better water absorption. Crude lime (IV-c) is injurious due to excess of alkalinity at localised spots and may even kill many of the growing buds. Ineffective influence of acid treatment indicates that the acid hydrolysis of sucrose probably unavailable to the growing cells due to physiological or chemical reasons or may be already present in excess or may have possibly caused desiccation in some cases through the exosmosis of water. The difference between the results obtained by dextrose and glucose (IV-g and i) which are chemically same (in the present experiment the former was in commercial and the later in pure form) is not well understood. Literatures do not provide enough evidence for the causes of the effectiveness or ineffectiveness of the various pre-treatments by chemical compounds.

General Conclusions and Suggestions

Unquestionably the composition and quality of the seed canes and suitable temperature, aeration and moisture content of the soil are the factors which govern the germination behaviour of the sugarcane buds. Hence in the long run it is always profitable to select healthy and well nourished canes for planting. Clements (1940) has suggested to grow the canes specifically for this purpose. A little modification in the original method can be easily effected to suit the local conditions. The canes are grown with a balanced supply of nutrients and water for about six months, then hardened for about a month (by stopping water and nutrient supply). After the hardening treatment a liberal supply of water and nutrients is again restored till planting time. The

method of hardening renders the buds less susceptible to mechanical injury. While preparing setts, middle portion of the stalk should be used leaving preferably three or five buds from each end. Pre-sowing treatments like hot-water dip, cold-water dip, lime-water dip, and nutrient-solution dip (sulphate of ammonia can be used) have several definite advantages and can be followed in case of poor germinating canes. It is always advisable to select a better quality sett for sowing rather than to subject the inferior ones to various pre-treatments. As stated by Clements (1940) it may be said that where the internal and edaphic conditions are all very favourable, the idiosyncrasies of the buds may be regarded with impunity, but where they are less than favourable, the minimum requirements of germination must be respected.

Two common local practices were followed by the author —(a) cutting of the seed canes a few days earlier to sowing (the delay in sowing may be caused due to several reasons). Partial desiccation does not bring any serious reduction in germination percentage but considerable care is necessary for not allowing the buds to dry up completely by covering trash and sprinkling water from time to time over the seed canes. (b) Dipping the planting material in well water or in ponds for a day or two prior to sowing—These waters are impregnated with calcium and plant nutrients leached from the soils and thus helpful in increasing the germination percentage. This may also be effective in the removal of growth inhibiting substances (Dillewijn, 1952), minimising white ant attack (Khanna, 1933) or killing of the eggs of the local sugarcane pests which may reside in the setts.

As a last measure, if patches appear in the fields due to ununiform germination, these may be filled up by replanting (in case of ratoon) or transplanting small germinated setts brought from a nursery (in case of planted canes). This practice, minimises the loss in yield to an appreciable measure.

Summary

1. The work was undertaken at Deoria (U.P.) to demonstrate to the farmers the possibility of improving the germination percentage of Sugarcane by a proper selection of the planting material and suitable sett treatment prior to planting.

2. The top buds germinate fast. The middle buds germinate comparatively at a slow pace but their percentage germination is the highest.

3. The temperatures higher than 35° C injure the buds when setts are dipped in hot water. But 35° C temperature of water improves germination of buds very appreciably.

4. By partial desiccation, the germination was delayed initially but percentage germination ultimately was higher than untreated buds.

5. Soaking setts in well water, treatment with lime water and nutrient solution improved germination of sugarcane buds.

REFERENCES

Bonner, J. (1950). "Plant Biochemistry". Academic Press, New York.
Brandes, E. W. and Klaphaak, P. J. (1923). *La Planter*, **71**: 371-72, 392-94, 412.
Choudhri, R. S. and Bhatnagar, V. B. (1953). Effect of certain growth regulating substances on the germination of sugarcane setts. *Jour. Sci. Res. (B.H.U.)*, **4**: 149-56.
Clements, H. F. (1940). Factors affecting the germination of sugarcane. *The Hawaiian Planters' Record*, **64**: 117-46.
Curtis, O. F. and Clark, D. G. (1950). "An Introduction to Plant Physiology". McGraw-Hill, New York: 485.
Dillewijn, C. V. (1952). "Botany of Sugarcane". Chronica Botanica, U.S.A.
Dutt, N. L. *et al.* (1938). A note on seed-setting and seed germination in certain sugarcanes. *Ind. Jour. Agr. Sci.*, **8**: 429-40.
Iyengar, K. (1951). Intraseasonal Growth variation and cultivation of sugarcane. *Nature*, **168**: 252.
Khanna, K. L. (1933). Soaking sugarcane setts—its effect on germination and growth. *Proc. Ind. Sci. Congr.*, **20**: 56.
———— (1935). Soaking seed canes—its effect on germination and growth. *Ibid.*, **22**: 364.
Lal, K. N. and Mukherjee, K. L. (1958). (a) Role of microelements in the carbohydrate metabolism of sugarcane. (unpublished). (b) Role of microelements in the nitrogen metabolism of sugarcane (unpublished).
Mukherjee, K. L. (1956). "Role of microelements in metabolism and growth of sugarcane". Ph.D. Thesis, B.H.U.
———— (1957). Know the plant diet. *Rural India*, **20**: 153-55.
———— and Mukherjee, B. (1959). "A Text Book of Crop Systematics". Indian Press, Allahabad. (In Press).
Rao, K. K. (1937). Studies on germination of sugarcane setts. *Proc. Ind. Sci. Congr.*, **24**: 367.
Rege, R. D. and Wagle, P. V. (1934). A preliminary investigation on the germination of sugarcane setts. *Ibid.*, **21**: 84.
Sharma, S. N. (1944). Effects of Physical stimuli on germination of sugarcane setts. M.Sc. Thesis, B.H.U., 1944.
Singh, B. N. *et al.* (1935). Influence of steeping in solutions of varying hydrogen-ion concentrations on the germination and early growth of canes. *Ind. Jour. Agr. Sci.*, **5**: 715-28.

A REVIEW OF SUGARCANE MANURIAL TRIALS IN UTTAR PRADESH

By

S. S. IYER and R. K. TANDON

(Sugarcane Research Station, Shahjahanpur, U.P.)

INTRODUCTION

MANURIAL experiments with different kinds of manures and fertilizers for testing their suitability for different crops under diverse soil and climatic conditions have been conducted in this State (Uttar Pradesh) for the past more than three quarters of a century. Experiments upto about 1930 were compiled and comprehensively analysed and interpreted in connection with the recommendations of the Fertilizers' Committee* of the (then) Imperial Council of Agricultural Research. The results along with those relating to other provinces and States in India were published by the Indian Council of Agricultural Research in three volumes (1934). Extensive manurial experiments on sugarcane (also other crops) with modern statistical designs have been in progress since 1932 both in this State and other States. As far as manuring of sugarcane crop is concerned a large number of technical papers have been published in different scientific journals giving the results of investigations carried out from time to time besides Departmental bulletins and leaflets. Certain special aspects of manuring of this crop have also been reviewed from time to time by various research workers. Among the more important of such reviews may be mentioned, 'Fertilizer experiments on sugarcane in India' by Rege (1941), 'Review on green-manuring practices in India' by Mukerjee and Agarwal (1950) and 'Manuring of sugarcane—a critical review' by Mukerjee and Varma (1950). In Uttar Pradesh extensive manurial experiments on sugarcane have been carried out during the past nearly three decades at the three Research Stations, viz., Shahjahanpur, Muzaffarnagar and Gorakhpur as well as in a large number of zonal centres scattered all over the State. These experiments totalling about 400 in number, covering the period of roughly from 1935 upto-date have been compiled systematically and statistically interpreted somewhat on the lines of the first 'Analysis of Manurial Experiments in India' by Vaidyanathan of the Indian Council of Agricultural Research (1934) cited above. While it is proposed to publish these detailed tables and the results soon, it is considered that a brief review of the main results obtained so far in this premier sugarcane growing State will be useful for assessing the achievements so far made and would also be of help in planning out the lines in which future work should be carried out on this important aspect of sugarcane cultivation.

Some of the earliest manurial experiments on sugarcane in Uttar Pradesh (*vide* supp. to Vol. I of Analysis of Manurial Expts. in India by Vaidyanathan, 1934) were carried out at Kanpur between 1897 and 1903 with saltpetre, castor cake, cowdung, poudrette etc. (in doses of 125 lb. N to 500 lb. N per acre) and in 1910 with calcium cyanamide, calcium nitrate and farmyard manure. Apart from general indications, no definite conclusions were reached from these early experiments. Later Kanpur experiments (1926 to 1931) with bonemeal, cowdung and different kinds of oil-cakes showed some effect (about 14 to 30 per cent increase in cane yield by the application of mustard cake and castor cake.) Experiments on Sugarcane with different manures were also conducted between 1923 and 1931 at Aligarh, Muzaffarnagar, Shahjahanpur, Gorakhpur and Pratapgarh. Ammonium sulphate, potassium sulphate, nitro-chalk and bonemeal were found good for sugarcane at Aligarh; castor cake and neem cake at Pratapgarh; green-rotted water hyacinth and dry water hyacinth at Gorakhpur and ammonium chloride, bonemeal and nitrophoska at Muzaffarnagar. Experiments at Shahjahanpur between 1928 and 1931 clearly established that green manuring with sanai (*Crotalaria juncea*) increases cane yields by about 33 per cent.

REVIEW OF MAIN RESULTS

Manurial experiments on sugarcane may conveniently be classified under levels and types of (i) bulky organic manures like farmyard manure, farm or municipal compost, cattle urine earth, molasses, pressmud, sugarcane trash (ii) green manuring crops (iii) light organics like castor cake, groundnut cake etc. (iv) inorganic fertilizers and (v) mixture of organic and inorganic fertilizers. Time and methods of application of manures, manuring in relation to irrigation, cultural operations like spacing, seed-rate etc. will be further classes in which the manurial experiments can be usefully classified and interpreted.

*Proc. First. Meet: Ferti. Comm. of ICAR (June 1930)

Bulky Organic Manures: A large number of experiments have been carried out with bulky organics like farmyard manure, farm compost, municipal compost, poudrette, cattle urine earth, molasses and pressmud. It has been found that farmyard manure when applied alone on equal nitrogen basis is inferior to, say, sulphate of ammonia or its mixture with sulphate of ammonia. Experiments carried out at Shahjahanpur and Muzaffarnagar during 1939 to 1944 for instance showed that even the lower dose of ammonium sulphate (60 lb. N) gave better cane yields than the higher nitrogen dose (100 or 120 lb.) as farm yard manure. At Shahjahanpur the average response with farmyard manure (100 lb. N) varied from 0·78 mds. of cane per lb. N to 1·61 mds. while for ammonium sulphate the responses were 2·28 to 3·98 mds. per lb. N. In the general manurial experiments comparing different organic and inorganic manures at Shahjahanpur carried out between 1938 and 1949, the response per lb. of N for farmyard manure and farm compost averaged 0·72 mds. cane while for ammonium sulphate the average response worked out to 1·72 mds. of cane per lb. N. In general, bulky organic manures like farmyard manure and compost give a lower response than inorganic fertilizers, the usual response being only about one md. of cane per lb. of nitrogen. As a top-dressing over a basal dose of *sanai* green manure, farmyard manure has proved as good as ammonium sulphate, castor cake or farm compost at Shahjahanpur (1939-42).

Molasses: A number of experiments carried out at Shahjahanpur (1935-38) with molasses showed that a dose of about 270 mds. per acre applied about two to four months before planting of cane is beneficial. Later experiments between 1938-39 and 1942-43 have also shown that molasses applied six to eight weeks before planting at the rate of 100 lb. N gives consistently better results than ammonium sulphate or cakes. Roughly the response is about one md. of cane per two mds. of molasses applied. At Muzaffarnagar molasses at about 200 mds. (30 lb. N) per acre gave as good results as Neem cake and was better than farmyard manure at 60 lb. N per acre. If the cost is reasonable and the soils are not acidic or otherwise unsuitable, molasses can be a good form of manure especially near sugar factory areas.

Sulphitation Pressmud: It is a rich source of nitrogen, potash, phosphoric acid and lime and has been extensively used as a manure at Shahjahanpur. This has given average increase in cane yields of 14 to 45 per cent. In an experiment carried out for five years (1945-46 to 1949-50) on the average pressmud cake increased cane yields by 28 per cent as compared to 70 per cent by ammonium sulphate, 17 per cent by farm yard manure, 26 per cent by compost, 20 per cent by urine earth and 18 per cent by molassic manure. The average response with pressmud cake based on eight years' trials at Shahjahanpur (1939-49) is of the order of one to two mds. cane per lb. N. About 200 mds. of pressmud per acre was considered sufficient for sugarcane crop at Muzaffarnagar. At Gorakhpur also pressmud (150 lb. N per acre) gave as good results as ammonium sulphate or ammonium nitrate during 1947-49.

Cattle urine-earth has been tried as a manure at all the three research stations, Shahjahanpur, Muzaffarnagar and Gorakhpur. The response per lb. N has invariably been better than farmyard manure.

Sugarcane trash: Compost prepared out of sugarcane trash has been used at Shahjahanpur for a number of years and has been found to be a valuable manure. In recent years the utility of incorporating cane trash directly into the field has been studied at Shahjahanpur. The direct application of cane trash (150 lb. N per acre) resulted in slightly lower cane yields than that of the compost made out of the trash in 1949-50. Next year (1950-51) it was found that incorporation of cane trash at 75 mds. per acre directly in the soil gave as good results as the same quantity converted into compost before application. Later it has been found that best results were obtained when cane trash was buried in July with ammonium sulphate alone or in combination with superphosphate and magnesium sulphate. Under autumn planting conditions incorporation of trash into the soil at 75 mds. per acre generally improved cane yields.

Other bulky organics tried include Poudrette (night soil) and bonemeal. Poudrette compares favourably with ammonium sulphate upto 200 lb. N per acre in increasing cane yields. Night soil can be used with advantage by trenching it directly in the cane field.

Bonemeal has given a response of ten per cent extra cane, but its utility will depend on its relative cost.

In general, bulky organic manures do not delay maturity of cane to the extent inorganics do.

Green manuring: Apart from the earlier experiments with *Sanai* already referred to, a great deal of experimentation has been carried out with different green manuring crops in all the research stations. Amongst the green manures tried at Shahjahanpur are Sanai (*Crotalartia juncea*), Lobia (*Vigna Catiang*), Guar (*Cyamopsis psoralioides*,) Dhaincha (*Sesbania Aculeata*), Soyabean (*Glycine Hispida*), Patada shevra (*Desmodium diffusum*), Berseem (*Trifolium alexandrinum*), Pea, Senji (*Melilotus parviflora*), and Metha (*Trigonella foenumgraecum*). On an average, *sanai* green manuring has given about 150 mds. of additional cane yields per acre. At Muzaffarnagar green manuring with *sanai* has been found to increase cane yields by even 250 mds. per acre. The total sugar outturn per acre is also markedly increased. *Sanai* (whole) after 50 to 60 days growth or *Sanai* under ground portion together with tops, leaves and branches (stems being used for fibre extraction) incorporated in the soil

have given equally good results. Of the various green manures tried *Patada shevra* failed completely; *Soyabean* showed poor prospects, *Lobia* was as good as *Sanai*, *Dhaincha* and *guar* were about equal on the average but poorer than *Sanai* under Shahjahanpur conditions. However, *Dhaincha* stands excessive rains somewhat better than *Sanai* and is being recommended for green manuring under such conditions and also for low-lying and salt-affected areas. Among winter green manure crops, *Senji* and *Metha* require good seed bed and moisture conditions for normal growth and hence have limited value as green manuring. From the manuring point of view these rabi green manuring crops appear to be as good as the Kharif crops like *sanai* and *lobia*. In general winter leguminous crops may be recommended for green manuring where *Kharif* green manures cannot be adopted. Pea is easy to grow and adds substantial amount of both organic matter and nitrogen.

In recent years a good deal of work has been carried out to see the effect of application of superphosphate to leguminous green manuring crops and the subsequent effect on cane yields. Phosphatic fertilizers applied at the rate of 100 lb. P_2O_5 per acre to legumes like *pea*, *senji*, *metha* and *berseem* have been found to give, on the average, five to ten per cent increased cane yields. Further experiments carried out in zonal centres have confirmed the utility of phosphatic manuring of green manure crops preceding sugarcane.

A remarkable result on the utility of green manuring has been obtained at Shahjahanpur during recent years. In the long term NPK trial in progress at this station since 1935-36 where continuous application of inorganic fertilizers alone had reduced the fertility to a very low level, the introduction of *sanai* green manuring in the rotation cane-fallow-cane has restored the original level of soil fertility and the cane yields are now showing a progressively increasing trend. In another interesting experiment on the application of paddy-husk to sanai green manuring crop it has been found that the addition of paddy-husk results in giving the soil 90 lb. N per acre as compared to the usual 60 lb. N per acre by *sanai* alone. At Gorakhpur different methods of application of P_2O_5 at 150 lbs. per acre (at sowing of green manure at the turning in of green manure, and at planting of cane) showed no significant differences, but on the whole, application of phosphate at planting of cane and at the time of turning in of green manure seemed to be better. Water hyacinth has been tried as a green manure in Gorakhpur and has proved to be as good as farmyard manure.

Oil cakes: Several oil cakes like castor cake, groundnut cake, linseed cake, *mahwa* cake, mustard cake, *neem* cake and *til* cake have been tried as manures for sugarcane. All the cakes tried excepting *mahwa* cake proved to be almost equal in value with regard to cane yields when applied on equal nitrogen basis. The addition of cakes generally increased the humus content of soil and lowered the C/N ratio without affecting the soil pH. At Shahjahanpur castor cake at 100-120 lb. N per acre gave average responses ranging from 1 to 2 4 mds. cane per lb. N and groundnut cake from 1·2 to 1·8 mds. cane per lb. N. A large number of experiments have been carried out with progressive doses of groundnut cake and castor cake at the three research stations. At Shahjahanpur it has been found that under average good conditions of cultivation the response is not perceptibly reduced even when doses upto 220 lb. Nitrogen per acre as groundnut cake are applied. About 34 mds. of groundnut cake per acre is considered as the optimum dose. Further, where manuring is desired to be done at high level it is better to use groundnut cake or castor cake rather than ammonium sulphate. Castor cake tried at Muzaffarnagar and Gorakhpur has given similar results, optimum level of nitrogen being 100 to 120 lb. N per acre. At Muzaffarnagar *neem* cake also gave good responses.

Broadly it may be stated that oil cakes (castor and groundnut cakes) when applied at the optimum level of 120 lb. N per acre give about $1\frac{1}{2}$ to $2\frac{1}{2}$ mds. of cane per lb. N. Possibility of further improving the efficiency of oil cakes as manure for cane is being investigated at the research stations.

Inorganic Fertilizers: Amongst the inorganic fertilizers tried are: ammonium sulphate, ammonium nitrate, ammonium sulphate nitrate, ammonium chloride, urea, potassium nitrate, calcium cyanamide, potassium sulphate and superphosphate.

One of the most important experiments conducted at Shahjahanpur is a long term NPK trial (cited before) which has been in progress since 1935-36. There are 27 treatments comprising the combinations of 3 levels of N (0 lb., 100 lb., 200 lb. per acre as ammonium sulphate) $\times$3 levels of P_2O_5 (0 lb., 75 lb. 150 lb. per acre as superphosphate) $\times$3 level of K_2O (0 lb , 75 lb., 150 lb. per acre as sulphate of potash), the layout remaining the same throughout and the rotation being cane-fallow-cane till 1952-53. This experiment which has now completed a period of 22 years has clearly established that it is only nitrogen that is deficient in these soils. In all the years nitrogen alone showed a response, the average responses for the first 100 lb. N being of the order of $2\frac{1}{2}$ mds. cane per lb. N. Phosphate and potash showed no effect showing thereby no signs of P_2O_5 or K_2O depletion in this soil. A statistical study of the trend of yields in this experiment has shown that the continuous application of sulphate of ammonia alone without any organic or green manuring is definitely deleterious to the soil. The yield of cane as well as the response to nitrogen were more or less maintained during the first four or five years but there has been a definite decline in both since then. As already mentioned under green manuring, the introduction of *sanai* as a green manuring crop in this experiment has now resulted in restoring the original soil fertility. Phosphate and Potash have not

shown any response even after the introduction of green manuring. Similar but short term experiments at Muzaffarnagar and Gorakhpur and also at a number of other centres also showed no effect of either potash or phosphate. In a series of general manurial trials (1938-39 to 1948-49) comparing different organic and inorganic manures, ammonium sulphate (100 to 120 lb. N) invariably gave good response, the average response varying from 1 to 4·63 mds. of cane per lb. N. Calcium Cyanamide gave an average (three years) response of 1·6 mds. of cane per lb. N and potassium nitrate 2·5 mds. per lb. N (average of four years). Ammonium nitrate gave good responses at Shahjahanpur during 1944-46 and 1946-47. At Muzaffarnagar ammonium nitrate gave average response similar to that of ammonium sulphate, but ammonium sulphate proved to be the best inorganic fertilizer. At Gorakhpur five years' results have shown that ammonium sulphate and ammonium nitrate give equally good responses. Chilean nitrate has also proved equally good as ammonium sulphate both at Muzaffarnagar and Gorakhpur. The responses for ammonium sulphate are somewhat better than that of chilean nitrate. In the permanent manurial trials at Muzaffarnagar the mixture of ammonium sulphate and groundnut cake has been found to give the best results. The optimum dose of manure for ratoons at Muzaffarnagar has been found to be 140 lb. N per acre as a mixture of ammonium sulphate and castor cake. Ammonium sulphate, ammonium nitrate and sodium nitrate show more or less the same effect on cane growth and juice quality. Urea has been found to be as efficacious as ammonium sulphate.

It may be stated that in general inorganic nitrogenous fertilizers like ammonium sulphate and ammonium nitrate give much higher response (2 to 3 mds. of cane per lb. N) than bulky organics like farmyard manure, compost etc.

Phosphates and Potash: As already stated phosphates and potash have not shown any response in cane yield in most of the experiments conducted in the research stations. There is some indication that application of superphosphate after completion of germination by dibbling 7″ deep near the root zone may be of some benefit. In a series of experiments at Shahjahanpur application of superphosphate or bonemeal (150 lb. P_2O_5) at three and six inches depth showed no appreciable response. At Muzaffarnagar also the application of phosphate by broadcasting or in trenches at 4″ and 7″ depth showed no response. Recently some response to direct application of phosphate has been obtained in certain special types of soils for instance in type II soils of Gorakhpur (leached calcium soils with a layer of calcium carbonate accumulation at the bottom), and in some soils of Gola and Baheri zones. Experiments are now in progress in other types of soils to investigate the utility of phosphate application, particularly over basal application of farmyard manure etc.

Though direct application of phosphate to sugarcane crop has not been found to be effective in most places as already stated the advantage of phosphatic manuring of legumes and their residual effects on the succeeding cane crop has been well established. Phosphate definitely improves the yield of green matter and subsequent yield of cane crop. The average increase in yield of cane due to 100 lb. P_2O_5 supplied to leguminous crops (*pea, senji, metha* and *lobia*) is about 65 mds. per acre.

Mixture of organic and inorganic fertilizers: A number of experiments have been carried out on the levels and types of mixture of organic and inorganic fertilizers. It has been found that the optimum dose of N for sugarcane is about 120 lb. N per acre. The most suitable combination appears to be organic manure (green manure plus farmyard manure or press mud) to supply 80 lb. and light organics (oil cakes) and inorganic fertilizers to supply the remaining 40 lb. N per acre.

Time of application of manure: Fractional application does not seem to be necessary for better utilization of manures in the doses commonly recommended in U.P. In general, application of oil cakes at planting to three to four weeks before planting seems to be the best. Ammonium sulphate may be most suitably applied at planting and/or at tillering time. Farmyard manure gives best results when applied eight weeks before and molasses about 10 to 12 weeks before planting cane. Late application of nitrogen at the break of rains or later has been found to delay the maturity of cane. Early application of nitrogen to the ratoon crop has been found to increase tillering in general.

Method of application: Castor cake and ammonium sulphate have been applied 1. Broadcast, 2. In furrows with setts, 3. In furrows along rows, 4. Dibbling. Application of fertilizers (castor cake or ammonium sulphate) near the setts in furrows with setts at planting is a good practice provided there is adequate moisture in the soil particularly if higher doses of nitrogen are applied. If the soil moisture is not of a high order germination will be adversely affected. Under favourable conditions, dibbling or application of manures with setts in furrows have been found to give better results than broadcasting manures. Dibbling is a costly process and is not recommended. Under normal cultivators' condition broadcasting is considered a safer practice. Other methods like application of the manure mixture as pellets at planting or as pellets or surface bands in May have not shown appreciable differences. During recent years application of ammonium sulphate or phosphate partly to soil and partly in the form of a weak solution sprayed on cane leaves has been tried but has shown no effect on cane yield or juice quality.

Manuring in relation to irrigation: A large number of experiments have been conducted at the Research Stations on the interaction of irrigation with manuring. At Shahjahanpur it has been found that within the range of three to six irrigations and 0 to 200 lb. N/acre no significant interaction between water and nitrogen could be noticed. At Muzaffarnagar while 120 lb. N/acre increased cane yields by 73 per cent with three irrigations, the increase was 103 per cent, with five irrigations showing a marked response to higher manuring with greater quantity of water.

Manuring in relation to spacing: The question of spacing depends mainly on the level of soil fertility. Experiments conducted at Shahjahanpur (1935-38) have shown that upto 50 lb. N/acre, the cane yields fall with increased spacing between the cane rows. At higher levels of manuring (100 and 200 lb. N) the yields increased with increased spacings. Further experiments at Muzaffarnagar and Shahjahanpur (1939-46) have shown that 3 ft. spacing between cane rows gives, on the whole, the optimum results. At 100 lb. N/acre, 4½ or 6 ft. spacings reduces cane yields by 75 to 90 mds. per acre. At the level of 200 lb. N/acre, 4½ ft. spacing gave a slightly higher yield than 3 ft. spacing but 6 ft. spacing reduced cane yields by about 60 mds. per acre.

Experiments with different seed rates and different levels of nitrogen are in progress at Shahjahanpur.

Summary

The response of sugarcane crop to nitrogenous fertilizers in the U.P. soils has been fully established. Phosphatic and potassic fertilizers, in general, when applied directly to sugarcane crop do not produce any significant response. Phosphate has shown some response in certain types of soils in Gorakhpur district as well as in Gola in Kheri district over a basal farmyard manure. Phosphatic fertilizers applied at the rate of 100 lb. P_2O_5 per acre to legumes like Pea, Senji (*melilotus parviflora*), Metha (*Trigonella foenumgraecum*) and Berseem (*Trifolium alexandrinum*) etc. have been found to give five to ten per cent increased yields of cane crop following these legumes.

Repeated application of high doses of inorganic fertilizers like sulphate of ammonia alone without any organic or green manuring results in progressive deterioration in cane yields. The addition of *sanai* green manure has been found to offset this tendency.

The optimum dose of N for sugarcane in our soils has been found to be about 120 lb. N/acre. The most suitable combination is organic manure (green manure plus farmyard manure or pressmud) to supply 80 lb. and light organic (oil cakes) and inorganic fertilizers (ammonium sulphate) to supply 40 lb. N per acre. The best time of application of manures like farmyard manure, compost, pressmud and molasses is about one and a half to two months before planting cane, oil cakes about a month before planting cane and inorganic fertilizers at planting time or soon after germination. Late application of nitrogen at the break of rains or later delays maturity of canes.

For certain types of soils the dose of nitrogen may usefully be raised from 120 lb. per acre to, for instance, 130 lb. in type I, 160 lb. in type IV/II and 180 lb. in type III soils.

Future Lines of Work

Inspite of the large number of experiments carried out so far with different types of organic manures, alone as well as in combination with inorganic fertilizers, further work on an intensified scale is required to elucidate the real part played by levels of organic matter in relation to (1) maintenance of soil fertility and (2) the responses produced by different nitrogenous, phosphatic and potassic inorganic fertilizers. The need for detailed soil studies and their classification with particular reference to their manurial requirements, suitable crop rotations etc. cannot be over-emphasized. Long term experiments in different soil types are needed to examine the cumulative effects of application of different organic and inorganic manures over long periods. Other lines which research work should aim at are (1) studies on soil deficiencies, (2) the changes in the nutrient balance of soil due to green manuring etc., (3) evolving suitable schedules of crop rotation and treatments to preserve the organic content of the soil, (4) use of locally occurring manuring substances e.g. paddy husk on which some work has been done, (5) use of indicator tests for finding out deficiency or otherwise of certain useful elements, (6) further use of catalysers, foliar sprayings etc. Above all, from a practical point of view there is urgent need to carry out more and more simple experiments in the actual cultivators' fields all over the State apart from the somewhat specialized conditions of Government research or experimental farms.

REFERENCES

Anonymous (1937). Manuring of sugarcane crop in the United Provinces, Leaflet No. 40, Department of Agriculture, U.P.

——— (1937). Use of molasses as manure, Leaflet No. 41, Department of Agriculture, U.P.

——— (1943). Useful hints for sugarcane cultivation. (Leaflet) in Hindi, contributed by Sugarcane Research Station, Muzaffarnagar.

——— (1930-40 to 1956-57). Annual Reports of Sugarcane Research Schemes, U.P.

Gahlot, K. N. S. (1954). Different forms of inorganic nitrogenous manures in sugarcane cultivation. *2nd Bien. Conf. Sugarcane Res. and Dev. Workers, Jullundur.*

Khan, I. A. and Agarwal, D. C. (1943). 'Effect of the method of application of cakes and inorganic fertilizers on germination in sugarcane'. *Proc. Sug. Tech. Assoc. of India.*

Kapoor, G. P. and Kishore, G. (1951). Comparative efficiency of various organic manures and inorganic fertilizers in western U.P. *Proc. First Bien. Conf. Sug. Res. & Dev. Workers, Coimbatore.*

Mukherji, B. K. and Agarwal, R. R. (1950). Review of green manuring practices in India. *Bull. No.* 58 *of Ind. Counl. of Agril. Res.*

Mitra, A. K. and Research Staff (1940). A note on the work done on the manurial value of molasses and pressmud. *Proc. Sugar Tech. Assoc., India.*

Mukherji, B. K. and Verma, G. (1950). Manuring of Sugarcane. *A critical Review, Proc. Sugar Tech. Assoc., India.*

——— (1951). The effect of continuous application of sulphate of ammonia alone and in conjunction with superphosphate and sulphate of potash on productivity of sugarcane soil. Symp. National Chemical Laboratory, Poona.

——— (1951). A note on Mahuwa cake and its use. *Agri. and Animal Husbandry, U.P.*

——— (1951). The Scientific manuring of crops in a rotation to build up soil fertility, *Proc. Bord of Agri. India, Indore.*

——— (1951). A review of green manuring methods already adopted and further measures to popularise its use for increasing yield particularly of food crops. *Ibid.*

Nagar, D. S. (1948). The effect of nitrogen application on ratoon crops of sugarcane. *Proc. of the* 16*th Annual Conv. of Sugar Tech. Assoc. of India.*

Pramanik, B. N. and Lal, J. B. (1937). Effect of organic and inorganic manures on the sucrose content purity of juice and cane yields. *Proc. of the 6th Annual Conv. of Sugar Tech. Assoc. of India.*

——— (1940). Green manuring of sugarcane with sanai, 'Hal' (Hindi).

Panje, R. R. (1951). A note on the utilisation of human excreta as manure for sugarcane, *Proc. First. Bien. Conf., Sugarcane Res. Workers,* Coimbatore.

Pramanik, B. N. and Misra, A. N. (1953). Effect of continuous manuring with artificial fertilizers on Azotobacter and Soil fertility. *Indian Jour. of Agri. Sc.,* **XXV**, Part I.

——— and Lal, J. B. (1954). Manuring and soil fertility with special emphasis on yield and quality of sugarcane crop. *2nd. Bien. Conf. Sug. Res. & Dev. Workers, Jullundur.*

——— and Misra, A. N. (1954). The role which soil bacteria play in crop production, *Ibid.*

Rege, R. D. (1941). Fertilizers Experiments on Sugarcane in India 1932-39. *Misc. Bull. No.* 41. Imp. Coun. of Agril. Res.

Tandon, R. K. and Misra, G. N. (1954). Fertilizers and Cane cultivation in Uttar Pradesh with special reference to phosphatic manuring. *2nd. Bien. Conf. Sugarcane Res. & Dev. Workers, Jullundur.*

Vaidyanathan, M. (1934). Analysis of Manurial Experiments in India. Vols. I to III. Imp. Counl. of Agril. Res.

EFFECT OF BORON AND MOLYBDENUM IN THE PRESENCE OF INORGANIC AND ORGANIC NITROGEN ON THE YIELD AND QUALITY OF SUGARCANE

By

HARBANS SINGH, RAJAT DE* and SEWA SINGH

(Sugarcane Research Station, Jullundur Cantt., Punjab)

INTRODUCTION

THE role of the micro-nutrient elements boron and molybdenum as essential elements of plant nutrition has been established beyond doubt (Hoagland, 1948). The part played by these elements in correcting deficiency symptoms and improving crop yields has been reported from various parts of the world (Brenchley, 1942; Wallace, 1950; Lal and Subba Rao, 1954).

Fertilization of sugarcane with artificial and organic fertilizers in India has not been so responsive as is warranted by the chemical nature of soils. Even nitrogen which has almost universal response under Indian conditions has failed to improve yields of sugarcane beyond a certain limit. The response to the higher doses of nitrogen at the Sugarcane Research Station, Jullundur, with a light soil and an alkaline reaction (ph 8·2) has not been so promising. De and Singh (1954) reported iron deficiency in these soils manifested by chlorotic symptoms in sugarcane foliage.

In order, therefore, to find out if association of micro-nutrients with the major elements could improve yields further, an experiment was laid out using nitrogen and phosphorus in combination with boron and molybdenum. The experiment which was carried out in two cropping seasons 1953-54 and 1954-55, with the sugarcane variety Co. L. 9 was laid out in a split-plot design in the following combinations which were replicated four times with a net plot size of 1/80th of an acre. The nitrogen treatments were assigned to the main plots.

N_0 No nitrogen N(A.S.) 100 lb. nitrogen per acre in Amm. sulphate N(G.N.) 100 lb. nitrogen per acre in groundnut cake	×	P_0 No phosphorus P_1 100 lb. P_2O_5 per acre as single super-phosphate	×	T_1 no micro-nutrient T_2 Mo in soil T_3 B in soil T_4 Mo as spray T_5 B as spray

Nitrogen in inorganic form as sulphate of ammonia and organic form as groundnut cake at 100 lbs. per acre was applied to the crops at planting in March-April in both the years. Phosphorus as single superphosphate at 100 lbs. P_2O_5 per acre was also applied at planting. The micro-nutrients—molybdenum and boron—were applied in two ways, in the soil and as sprays to the foliage. Molybdenum as ammonium molybdate at two lbs. and boron as boric acid at five lbs. per acre were incorporated into the soil after the germination of the setts was complete. The two chemicals were mixed with a large volume of dry soil and applied to the plots. For spray to the foliage these chemicals, dissolved in water and mixed with soap solution to act as an emulsifying agent, were applied at the same rate as in soil, i.e., 2 lbs. ammonium molybdate and five lbs. boric acid per acre, when the crop had completed its tillering phase (three months old). One hundred gallons of solution per acre were required in each case.

EXPERIMENTAL FINDINGS AND DISCUSSION

Observations on tillering, yield, juice quality and nitrogen uptake were recorded in both the years and some of the more important results are given below.

Tillering

Differences due to the nitrogenous fertilizers (Table I) were significant in both the years. Micro-nutrients did not influence any significant changes though the spray applications were found to be a little better utilized than the soil applications. None of the interactions were significant.

*Now Plant Physiologist, Central Potato Research Institute, Simla, Punjab.

TABLE I

Tiller Production

Treatment	N_0		N(A.S.)		N(G.N.)		Mean for T's	C.D. at 5 per cent
	P_0	P_1	P_0	P_1	P_0	P_1		
1953–54 (July)								
T_1 No micro-nutrient ..	5·3	6·1	7·1	6·3	6·7	7·2	6·53	
T_2 Mo in soil	6·1	6·1	6·6	6·1	6·2	6·8	6·32	
T_3 B in soil	5·8	6·5	7·6	6·7	6·5	6·2	6·55	
T_4 Mo spray	5·9	6·1	6·9	6·8	7·0	6·6	6·55	
T_5 B spray	5·9	6·1	7·2	6·8	7·5	7·7	6·87	±0·58

Mean for N_0 – 6·0; N(A.S.) – 6·9; N(G.N.) – 6·9; C.D. ± 0·60
Mean for P_0 – 6·5; P_1 – 6·6 C.D. ± 0·53

Treatment	N_0		N(A.S.)		N(G.N.)		Mean for T's	C.D. at 5 per cent
1954–55 (July)								
T_1 No micro-nutrient ..	6·2	6·4	7·5	7·7	7·8	8·1	7·32	
T_2 Mo in soil	7·8	5·5	7·7	8·0	7·7	7·7	7·40	
T_3 B in soil	7·2	7·0	7·9	8·0	7·3	7·2	7·43	
T_4 Mo spray	7·1	7·3	7·9	7·9	7·4	7·3	7·48	
T_5 B spray	6·3	6·7	6·9	7·7	7·7	7·7	7·17	±0·76

Mean for N_0 – 6·8; N(A.S.) – 7·7; N(G.N.) – 7·6 C.D. ± 0·72
Mean for P_0 – 6·5; P_1 – 7·4 C.D. ± 1·90

Yield

The application of nitrogen improved yield of the crop significantly in both the years; the differences amongst the two sources of nitrogen were, however, non-significant. The micro-nutrients in the first year of experimentation had no discernible influence on the cane yield, but in the second year the spray application of both these elements significantly improved the cane yield. The soil applications of either molybdenum or boron had very little effect on yield in either of the two years.

TABLE II

Yield of Millable Canes per acre (in mds.)

Treatment	N_0		N(A.S.)		N(G.N.)		Mean for T's	C.D. at 5 per cent
	P_0	P_1	P_0	P_1	P_0	P_1		
1953–54								
T_1 No micro-nutrient ..	518·5	656·5	645·0	627·0	555·5	559·5	593·7	
T_2 Mo in soil	537·5	481·0	619·0	649·5	620·5	597·0	584·1	
T_3 B in soil	598·7	507·5	589·0	603·0	656·5	640·0	599·1	
T_4 Mo spray	542·0	496·0	587·5	658·5	706·0	606·0	599·0	
T_5 B spray	512·5	589·5	530·5	617·0	589·0	643·5	580·2	±57·4

Mean for N_0 – 544·0; N(A.S.) – 612·6; N(G.N.) – 617·4 C.D.±67·8
Mean for P_0 – 587·1; P_0 – 595·4 C.D.±65·4

TABLE II—(*Contd.*).

Treatment	N_0 P_0	N_0 P_I	N(A.S.) P_0	N(A.S.) P_I	N(G.N.) P_0	N(G.N.) P_I	Mean for T's	C.D. at 5 per cent
				1954–55				
T_I No micro-nutrient ..	619·5	633·5	664·5	689·0	709·5	736·5	675·4	
T_2 Mo in soil	624·5	641·5	662·0	690·5	674·5	774·0	677·8	
T_3 B in soil	650·0	662·5	691·5	679·5	689·5	696·5	678·5	
T_4 Mo spray	647·0	680·5	708·0	776·5	721·0	730·0	710·5	
T_5 B spray	669·5	687·5	723·5	742·5	687·0	720·5	705·1	±25·7

Mean for N_0 – 651·6; N(A.S.) – 702·7; (N(G.N.) – 713·9 C.D.±30·7
Mean for P_0 – 676·1; P_I – 702·7 C.D.±25·2

Although the yield of the crop due to the micro-nutrients, in the first year of experimentation improved in certain cases it did not reach the level of significance. It was probably due to the fact that in the first year the replications were laid out at different places with soil variation, and at one place the results of two replications were vitiated by a heavy top-borer attack.

Phosphate application only during the second year showed an improvement in cane yield. Here again, location of all the replications in the same fields seems to be responsible for higher yield due to phosphorus treatment in the second year. None of the interactions were significant.

Number of millable canes

The above trend of results was also reflected in the number of millable canes harvested per acre.

TABLE III

Number of millable canes (in thousands) per acre

Treatment	N_0		N(A.S.)		N(G.N.)		Mean for T's	C.D. at 5 per cent
	P_0	P_I	P_0	P_I	P_0	P_I		
			1953–54					
T_I No micro-nutrient ..	45·7	50·6	54·5	58·9	58·0	58·9	54·4	
T_2 Mo in soil	48·5	51·5	57·3	59·6	56·1	58·4	55·2	
T_3 B in soil	48·7	48·0	54·6	58·3	59·7	62·8	55·4	
T_4 Mo spray	48·0	52·4	61·9	62·2	65·9	67·5	59·7	
T_5 B spray	51·0	53·1	57·3	59·8	58·8	60·0	56·8	±0·73

Mean for N_0 – 51·8; N(A.S.) – 58·5; N(G.N.) – 60·6 C.D. ± 3·67
Mean for P_0 – 55·1; P_I – 57·5 C.D. ± 3·02

Treatment	N_0 P_0	N_0 P_I	N(A.S.) P_0	N(A.S.) P_I	N(G.N.) P_0	N(G.N.) P_I	Mean for T's	C.D. at 5 per cent
			1954–55					
T_I No micro-nutrient ..	49·9	51·8	64·2	66·2	62·1	62·4	59·4	
T_2 Mo in soil	53·7	55·8	63·1	62·6	62·4	65·8	60·6	
T_3 B in soil	55·2	61·1	60·6	63·6	64·7	67·4	62·1	
T_4 Mo spray	55·6	59·6	67·9	69·9	68·9	70·6	65·4	
T_5 B spray	54·1	57·6	68·8	67·4	60·1	69·9	63·9	±3·64

Mean for N_0 – 55·4; (NA.S.) – 65·4; N(G.N.) – 66·0 C.D. ± 3·34
Mean for P_0 – 55·1; P_I – 63·5 C.D. ± 2·71

Here also nitrogen showed a significant response. No action of phosphorus was noticeable. Both the micro-nutrients in spray applications gave highly positive significant response on the cane number, but their application through soil was more or less ineffective. The beneficial effect of the micro-nutrients was noticeable in both the years.

TABLE IV

Sucrose percentage in juice

Treatment	N_0		N(A.S.)		N(G.N.)		Mean for T's	C.D. at 5 per cent
	P_0	P_1	P_0	P_1	P_0	P_1		
1953–54 (December)								
T_1 No micro-nutrient ..	16·4	16·5	15·5	15·9	15·0	15·5	15·8	
T_2 Mo in soil	16·3	15·9	15·6	16·0	16·1	15·7	15·9	
T_3 B in soil	16·3	16·2	15·1	16·2	16·4	15·6	16·0	
T_4 Mo spray	15·8	16·4	16·4	15·9	16·0	15·9	15·8	
T_5 B spray	16·4	16·2	15·5	15·4	16·1	16·2	16·0	±0·32
Mean for N_0 – 16·2; N(A.S.) – 15·7; N(G.N.) – 15·9 C.D. ± 0·55								
Mean for P_0 – 15·9; P_1 – 16·0 C.D. ± 0·45								
1954–55 (December)								
T_1	13·7	13·4	13·0	13·3	13·7	12·9	13·3	
T_2	13·8	13·7	13·3	13·6	13·8	13·6	13·6	
T_3	13·5	14·1	13·2	13·3	13·6	13·0	13·4	
T_4	13·7	13·1	13·5	12·9	13·1	12·5	13·1	
T_5	14·0	13·8	13·1	13·7	13·7	13·3	13·6	±0·52

Mean for N_0 – 13·65; N(A.S.) – 13·25; N(G.N.) – 13·30 C.D. ± 0·32
Mean for P_0 – 13·50; P_1 – 13·31 C.D. ± 0·25

Juice quality

Except for nitrogen application depressing the sucrose formation and delaying maturity early in the crushing season (Nov.-Dec. period) none of the other treatments seem to have any significant effect on the quality of cane juice.

Nitrogen uptake

Homologous leaves from different treatments were obtained in the pre-monsoon (June) and post-monsoon (September) periods in both the years and analysed for their total nitrogen content. Summarized results are presented in Table V.

Nitrogen uptake by the plants was higher where nitrogen was provided in the external medium. Micro-nutrient treatments also improved the efficiency of nitrogen absorption by the plants. In this case again the spray applications were generally found to be better than the soil applications.

It will be clear from the foregoing that the effects of nitrogenous fertilizers and the micro-nutrient elements were significant on certain of the yield characters and quality of sugarcane crop. Increased nitrogen applications improved tillering, increased yield but delayed maturity of juice. The two sources of nitrogen, however, failed to show any significant variation amongst themselves. Das (1936), Borden (1948), and Lal (1951) have also reported a similar trend in the response to nitrogen by the sugarcane crop.

Application of micro-nutrients has shown a beneficial effect on the millable cane counts and cane yield. Of the two methods of application, spraying the foliage with these elements proved better than the soil application. In the second year of experimentation, the spray application of the nutrients proved distinctly superior to the other treatments and compared to boron, molybdenum was more helpful in this respect. Lal

TABLE V

Nitrogen content of leaves

Treatment	1953–54		1954–55		Mean
	Pre-monsoon	Post-monsoon	Pre-monsoon	Post-monsoon	
N_0 No nitrogen	1·330	1·123	1·576	1·156	1·296
N(A.S.) 100 lb. N as Am. Sulph.	1·551	1·322	1·810	1·345	1·507
N(G.N.) 100 lb. N as G. N. Cake	1·393	1·289	1·792	1·296	1·442
P_0 No phosphorus ..	1·120	1·257	1·719	1·262	1·319
P_1 100 lb. P_2O_5 as super phos.	1·064	1·232	1·733	1·267	1·324
T_1 No micro-nutrient ..	1·346	1·248	1·764	1·439	1·449
T_2 Mo in soil	1·425	1·134	1·708	1·531	1·449
T_3 B in soil	1·442	1·321	1·602	1·517	1·470
T_4 Mo spray	1·458	1·206	1·617	1·590	1·468
T_5 B spray	1·386	1·312	1·781	1·509	1·497
Mean	1·352	1·244	1·710	1·391	

and Srivastava (1948) in their experiments with boron on sugarcane also reported the beneficial effects of boron in improving the growth of the crop.

The comparatively lesser efficiency of the soil application of these nutrients may probably be due to the absorption of these elements by the clay particles rendering them unavailable to the plants. By foliage application the nutrients were brought in the immediate vicinity of the actively metabolizing surface and taken up readily in the metabolic process of the plant.

It will be interesting to note that the nitrogen absorption by the plant followed a similar pattern as is reflected in the yield of the crop. Both the nitrogen application and the spray application of the micro-nutrients brought about a superior protein status of the plants.

Mulder (1948) in his experiments with *Aspergillus niger* and higher plants indicated the role of molybdenum in the reduction of nitrates in plants. In sugarcane also this element seems to have helped in greater protein synthesis which leads to a greater vegetative growth and higher yield of the crop. Boron which is known as an activator of meristematic growth seems to have had its effect here.

SUMMARY

An experiment has been reported on the effect of micro-nutrient elements—boron and molybdenum—on the yield and quality of sugarcane crop in the presence of nitrogeneous and phosphatic fertilizers. Two methods of micro-nutrient application has been tried, through soil and by foliage application. In the matter of improving cane yield, fertilization with nitrogen and application of the micro-nutrients as spray have been found to be useful. These two treatments also improved the protein content of the plants.

REFERENCES

Borden, R. J. (1948). Nitrogen effects upon the yield and composition of sugarcane. *Hawaian Planters' Rec.*, **52**: 1-58.
Brenchley, W. E. (1942). Value of molybdenum for lettuce. *Nature*, **194**: 196.
Das, U. K. (1936). Nitrogen nutrition of sugarcane. *Plant Physiol*, **11**: 251-317.
De, Rajat and Singh, H. (1954). A note on the chlorosis of sugarcane. *Proc. Sec. Bien. Conf. Sugarcane Res. & Dev. Workers*, **2**: 16.
Hoagland, D. R. (1948). Lectures on the Inorganic Nutrition of Plants. Chronica Botanica Inc.
Lal, K. N. (1951). Physiological role of nitrogen on growth and metabolism of sugarcane. *Proc. Nation. Inst. Sci. India*, **17**: 78-98.
———— and Srivastava, S. (1948). Role of boron in crop production. *Sci. and Cult.*, **14**: 57-62.
———— and Subba Rao, M. S. (1954). Micro-element Nutrition of Plants. B. H. U. Press.
Mulder, E. G. (1948). Importance of molybdenum in the nitrogen metabolism of micro-organisms and higher plants. *Plant and Soil.*, **1**: 94-119.
Wallace, T. (1950). Trace Elements in Plant Physiology.

CONTROL CAMPAIGN AGAINST STEM BORER, *CHILO TUMIDICOSTALIS* AT PLASSEY (WEST BENGAL)

By

B. D. GUPTA

(Indian Institute of Sugarcane Research, Lucknow, U.P.)

THE Stem borer, *Chilo tumidicostalis* Hmpsn. formerly known as *Argyria tumidicostalis* was recorded by Fletcher and Ghosh (1919) from the states of Bengal and Assam. It was also reported to occur in Purnea district (Bihar). But very little was known about its biology and life history till 1956, when it occurred in an epidemic form at the sugarcane farms belonging to Messrs. Ramnugger Cane and Sugar Co. Ltd., Plassey (West Bengal). This opportunity was utilised for collecting observations on the habits and life history as well as its control methods.

NATURE AND EXTENT OF DAMAGE

The presence of the borer was indicated by the dry crown of leaves in some of the canes of the infested clumps. Close examination revealed that the borer injury to the cane sticks was of two distinct kinds as detailed in the following:

Primary infection: It was caused by the newly hatched larvae congregating in the top three to five internodes of a cane. Fifty to as many as 156 caterpillars could be collected from one infested top. Top leaves of such canes were either completely dry or were drying. Red coloured frass was noticed oozing out from borer holes in the top internodes; while sett-roots came out profusely from the nodes and enveloped the cane stalk in a network of rootlets and root hairs. Side shoots were also seen sprouting out in some cases.

Secondary infestation: Grown up borer larvae migrated to neighbouring canes, or to the lower healthy portion of the canes showing primary infection and gave rise to what may be termed the " Secondary attack ". Cane tops did not dry up in this case, and individual caterpillars damaged one to five internodes.

The borer was observed to severely infest the autumn planted crop of Co. 419, Co. 453, Co. 527 and B.O. 11, over an area of about 200 acres. Ten month old crops of these varieties were not only quite tall and luxuriant in growth but were also likely to yield approximately 1,000 mds. of cane per acre. The extent of infestation in July 1956 varied from 95 to 100 per cent in these varieties; while the intensity of borer attack, as judged by the number of damaged internodes, was about 25 per cent. Another 1,200 acres of neighbouring cane showed slightly less infestation. The cultivators crop was also examined for borer infestation in the neighbouring villages of Loknathpur, Reginagar, Takipur, Dadpur, Surutia, Beldanga and Gopinathpur. However, the borer attack on the whole was low.

BIOLOGY

The moths emerged out at night and were easily attracted to light. Mating and egglaying also took place only at night. The eggmasses were deposited in typical pyralid fashion on the underside of the first, second and third recently opened top leaves, in tiers of two to four eggs. They were greyish in colour and could be easily spotted. The number of eggs in an eggmass varied from 90 to as many as 250. Hatching occurred in the morning hours after a week's incubation. The eggs in an eggmass hatched out simultaneously and all the newly hatched caterpillars penetrated into one of the top internodes. After a period of about ten days, the borer larvae dispersed to adjoining canes, each boring a separate internode. An individual life cycle took 44 to 83 days viz., incubation seven days, larval period 27-70 days and pupal stage from six to ten days in September. There was overlapping of broods and all the stages of pest were met-with in the fields simultaneously.

CONTROL CAMPAIGN (JULY TO SEPTEMBER 1956)

The programme of large scale control campaign was, therefore, immediately drawn up for bringing down the borer infestation and checking its spread to the surrounding areas. As already stated earlier, at the factory farm about 200 acres of the sugarcane crop had almost 100 per cent borer attack; while 1,200 acres were not so badly damaged. Therefore, the programme was so drawn up as to cater to the needs of both.

Fig. Showing primary infested tops removed from canes in a heavily damaged field.

The mechanical control measures were based on habits of the adults as well as the young ones (i) Adult moths were highly attracted to light points, (ii) the newly hatched caterpillars congregated into the cane tops, and (iii) the grey coloured eggmasses were mostly deposited on the first three top leaves. In order to save the crop from heavy infestation, attempts were made to spray Endrin and D.D.T. The control operations were continued till the middle of September. So far as the question of cultivators' crop went, the farm authorities were requested to mobilise the farmers and get the tops showing primary infestation removed and destroyed.

As many as 78 light traps were set up in 200 acres of the heavily infested areas and about 90,500 moths were trapped and killed. Besides, 2,54,370 eggmasses were collected and destroyed. As regards the removal of the cane tops showing primary infection, no quantitative data could be maintained since all the cane clumps showed primary attack.

Preliminary trials with D.D.T. and Endrin were first carried out in Plassey and Kadamkhali farms in August 1956. One pound of actual chemical was sprayed per acre singly as well as in combination against control. Neither D.D.T. nor Endrin could check the borer infestation from spreading to unaffected fields. Application of a mixture of the two insecticides in equal proportions, however, showed a decrease of 56·7 per cent in borer attack after four weeks of spraying. Large scale application of Endrin and D.D.T. at 0·1 per cent strength over 600 acres did not give any encouraging results as the incidence in the treated crop was about 50 per cent under both the insecticides.

Efficacy of two insecticides was further tested by fastening eggmasses on Endrin and D.D.T. sprayed leaves in some of the sugarcane fields. About 18·7 per cent of the canes got new infestation in the plots sprayed with Endrin and D.D.T., respectively.

Assessment of Borer Infestation at Harvest

Borer incidence was recorded in the cultivators crops as well as at the factory farms to assess the extent of borer infestation and to determine as to how far the large scale operations carried out in the latter were able to check the spread of the pest in the neighbouring villages. The borer incidence was high in Tejnugger,

Plassey, Soluabanki, Chandanpur, Kadamkhali, Char 20, Poliamat and Manikdihi farms of the factory and ranged between 50 to 75 per cent. On the other hand the infestation in cultivator's fields in villages Paglachandi, Debogram, Murshidabad, Patara, Mirzapur, Saktipur, Sahebnagar, Sargachi, Badkulla, Bahadurpur and Kamari-ranged between 5 and 15 per cent though it was as high as 32 per cent in Char because of heavily infested factory crops in the neighbourhood. This indicated that the control measures were quite effective in checking the spread of the borer into neighbouring villages.

Control Campaign (February to July 1957)

The borer resumed its activity from the beginning of February 1957 and, therefore, the control campaign was re-started by the middle of February and continued till the middle of July 1957. The details of the operation and the results achieved therefrom are given in the following paragraphs.

Mechanical control: The details of the moths as well as the eggmasses collected from an area of about 1,000 acres every week during the period February to July 1957, are given in Table I.

Table I

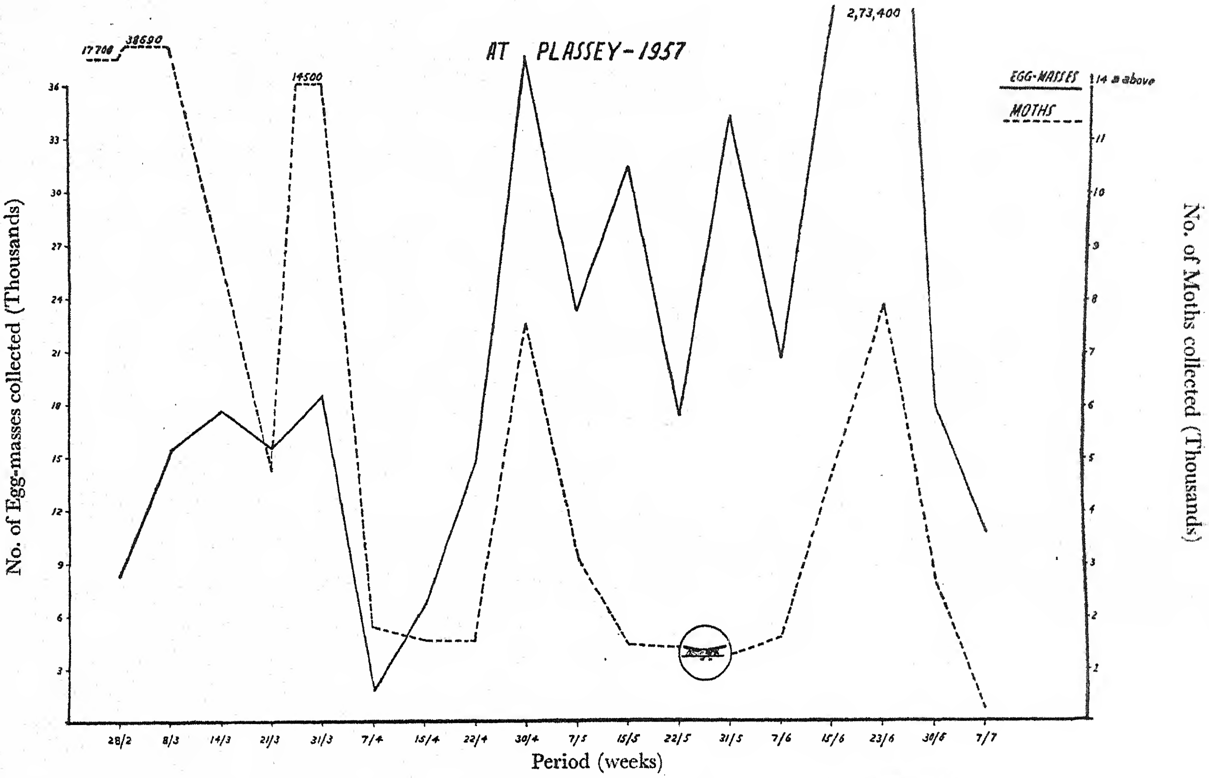
Number of eggmasses and moths collected during February-July, 1957

Week ending	Eggmasses collected	No. of moths collected	
		At light	By hand
28-2-57	8,761	16,313	1,439
8-3-57	15,452	35,380	3,310
14-3-57	17,624	4,144	2,662
21-3-57	15,569	4,563	261
31-3-57	18,660	14,423	63
7-4-57	1,824	1,789	12
15-4-57	6,694	1,430	116
22-4-57	14,923	1,083	454
30-4-57	37,671	6,024	1,553
7-5-57	23,285	2,504	609
15-5-57	31,492	1,291	182
22-5-57	17,370	1,874	538
31-5-57	34,307	1,025	288
7-6-57	20,841	1,269	335
23-6-57	2,73,325	5,807	2,132
30-6-57	17,911	2,158	533
7-7-57	10,805	251	..
Total ..	5,66,514	1,01,328	14,487

As regards the efficacy of the operations it might be said that even if one eggmass is taken to have only one hundred eggs on an average, about fifty million eggs were destroyed during the course of the campaign. On the other hand destruction of about one lac and sixteen thousand moths by light trapping and hand netting definitely reduced the potential danger to the crop for the rest of the season.

Chemical control: In March, 1957, in view of the huge collection of moths as well as the eggmasses, the factory authorities became restive and requested that the question of aerial spraying with some chemical may be given effect to. The question was discussed in detail and they were advised to spray one pound of Endrin 20 per cent emulsion concentrate per acre in the first week of April 1957. But the farm authorities undertook ground and aerial spraying operations during the last week of May 1958. In both the operations 2·5 lb. of Endrin (0·5 lb. actual) emulsion was sprayed per acre *i.e.*, one gallon of emulsion was used in four

GRAPH 1



Progress of mechanical control campaign against the stem borer *chilo tumidicostalis*

gallons of water per acre. In all 6,191 acres were sprayed out of which about 1,500 acres were treated through aerial spraying. D.D.T. and B.H.C. mixture was also sprayed in some of the fields. However, care was taken to mark out some of the blocks for the sake of comparison as regards the efficacy of the different treatments.

The borer infestation in the treated as well as untreated areas was recorded during the month of July 1957. It was observed that the fields, where mechanical control was undertaken before and after the spraying operations, showed an incidence varying from 6·0 to 20·0 per cent; while fields where no mechanical control was undertaken after spraying with Endrin had an infestation varying between 30·0 and 52·0 per cent. It appears that at some places the operations were carried out at a time when the brood was on the decline (graph I). Had the spraying been effective the subsequent oviposition ought not to have been so heavy.

The efficacy of the operations was also assessed at harvest in January 1958 from Co. 453 in some of the blocks at the factory farm through an examination of 1,000 canes as detailed below:

TABLE II

Efficacy of treatments on borer incidence and population

Blocks	Treatment for Borer control	Borer incidence (per cent)	Borer affected internodes (per cent)	Total number of borers found in 100 canes examined	Economic of the treatments per acre (Rs.)
Poistee	Mechanical control only	23·6	4·3	7·7	12·00
Daftri	Ground spraying with Endrin (No mechanical control after spraying)	32·9	4·0	8·7	21·00
Bartala	Ground spraying with D.D.T. and BHC mixture (No. mechanical control after spraying)	27·4	4·1	23·4	14·50
Shibpur	Aerial spray with Endrin (No mechanical control after spray)	37·4	6·0	12·9	26·50

ECONOMICS OF CONTROL OPERATIONS

The cost of mechanical control measures worked out to Rs. 2/- per acre per month for the collection of the borer eggmasses and the removal of the infested shoots as also putting up the light traps for the collection of the moths. The expenditure incurred during the period February to July 1957 amounted to about Rs. 12/- per acre.

The ground spraying with Endrin 20 per cent emulsion cost Rs. 16·50 for the insecticide and Rs. 4·50 per acre for the operation, the total cost being Rs. 21·00 per acre.

Application of B.H.C. and D.D.T. mixture cost Rs. 10·00 (Rs. 6·00 for B.H.C. and Rs. 4·00 for D.D.T.) per acre for the insecticides and Rs. 4·50 per acre for the operation amounting to a total cost of Rs. 14·50 per acre.

Aerial spraying cost Rs. 10·00 per acre (according to latest rates prescribed by the Plant Protection Directorate) besides a sum of Rs. 16·50 for 0·25 lb. of Endrin emulsion per acre, the total cost of operation being Rs. 26·50 per acre.

It is evident from the above that the mechanical control operations were not only superior to chemical control but were also the most economical of all the treatments.

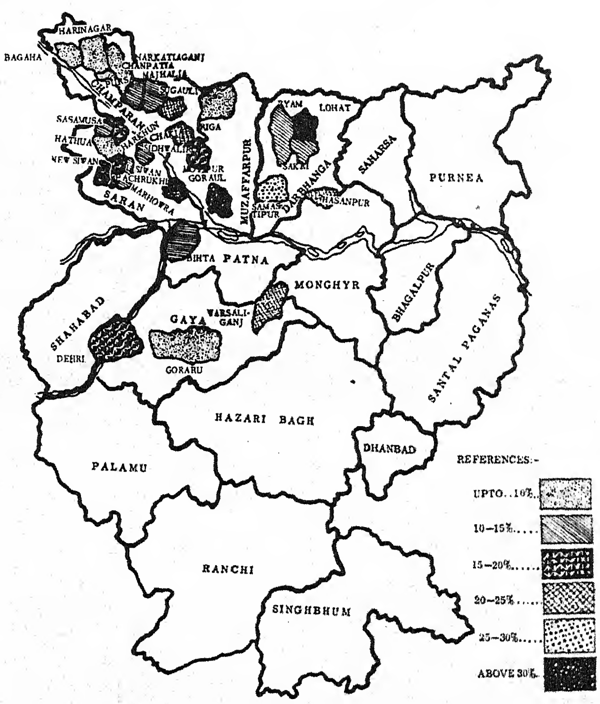
Miscellany

UNPRECEDENTED HEAT WAVE DURING APRIL-JUNE PERIOD IN BIHAR AND ITS ATTENDANT CONSEQUENCES

DURING the hot weather of 1958, an unprecedented heat wave was experienced throughout the sugar districts. Normally the maximum temperature did not cross the 108°F–111°F limit in different parts and the highest temperature epoch did not last for more than a couple of days at a time. During the 1958 summer, however, the temperature range was 114°F to 119°F and it was prolonged over a period of two to five weeks in different areas. In a State where sugarcane cropping is largely ' a gamble in the monsoon ' and where millable crop is directly the result of premonsoon tillering, such an unusual phenomenon cannot but affect the crop adversely. It was, therefore, decided to plan out a comprehensive questionnaire covering not only the intensity of the adverse feature and its duration but also its effect on crop growth in different areas covering different soil types and conditions of growth.

This questionnaire was duly issued and replies received from different sources viz. factory managements, plantation estates and Cane Development staff were carefully scrutinised, the mean incidence for the district and the extent of damage being arranged in a frequency table and Fig. So far as north Champaran was concerned, areas in Bagaha, Harinagar, Narkatiagunj, Lauriya and Chanpatia showed negligible damage but the incidence towards the south was as high as 15 to 20 per cent. In Saran, the damage varied from 5 to 35 per cent, the mean incidence for the district being 16 per cent. Cane areas in Muzaffarpur and Darbhanga districts were the worst victims of the scorching heat-wave. In south Bihar also, where irrigation facilities of some sort are available, the incidence varied between 16 to 20 per cent.

MAP SHOWING HEAT WAVE INCIDENCE IN BIHAR.



In sandy and light soils the damage to the crop was very severe with che result that in certain areas, fields have had to be ploughed up with a view to raise a monsoon crop. In general, under such conditions, damage to the extent of 40 to 60 per cent has not been infrequent.

As at present estimated, the crush will go down by a couple of lakh maunds in each milling unit so that the expected 8·5 lakh maunds crop may be reduced to possibly 8 lakh maunds or even less.—(K. L. KHANNA, Sugarcane Research Institute, Pusa, Bihar.)

Table Showing Extent of Damage due to Heat-wave on Sugarcane in different Districts

Range %	Champaran Centre	(17) dam-age %	Saran Centre	(14) dam-age %	Muzaffarpur centre	(8) dam-age %	Darbhanga centre	(11) dam-age %	Patna centre	(2) dam-age %	Gaya centre	(3) dam-age %	Shaha-bad centre	(1) dam-age %	Bihar (56) total
	Bagaha (F)	1	Hathua (F)	8	Righa (f)	2–3	Manigachi (A.I.)	5	..		Warsali-ganj (F)		..		
	Harinagar (f)	10	Hathua (A.I.)	8	Sitamerhi (A.I.)						Gaya (A.I.)	10			25
	Narinagar (A.I.)	3	Mirgunj (A.I.)	8		2–3						10			
	Narkatiaganj (f)	5	Herkhua (A.I.)	16	Motipur (F)	6–8									
UPTO 10	Narkatiaganj A-I	10	Mairwa (A.I.)	6–7											
	Lauriya (f)	0	Barulia	5											
	Lauriya (A.I.)	10													
	Gaunha (A.I.)	10													
	Chanpattia (F)	0													
	Chanpattia (A.I.)	0													
	Motihari (F)	4													
	Chakia (A.I.)	2–3													
	Majhaulia (F)	5													
11 to 15	Sugauli (F)	15	Sasamusa (F)	10–15			Sakri (F)	10–15	Bihta (F)	12	..		..		8
			Sasamusa (A.I.)	15	..										
			Sidwalia (A.I.)	15			Sakri (A.I.)	10–15							
							Lohat (F)	15							
16 to 20	Bettiah (A.I.)	15–20	New Siwan (F)	18	Motipur (A.I.)	15-20	Ryam (F)	15–20	Maner (A.I.)	20	..		Dehri (A.D.A.)	20	10
			Sidwalia (F)	15–20											
			Pachrukhi (F)	15–20	Kanti (A.I.)	15–20	Madhubani (A.I).	16							
21 to 25	Chakia (F)	25	..		..		Rosera (A.I)	20–25	..				..		3
							Hasanpur (A.I.)	20–25							
26 to 30	Chakia (A.I.)	30	Marhowrah (A.I.)	29	..		Samastipur (A.I.)	25–30	..		Tilaya (A.I.)		..		5
							Kishanpur (A.I.)					25–30			
Above 30	..		Marhowrah (F)	35	Goraul (F)	40	Lohat (A.I.)	50	..		..		..		5
					Goraul (A.I.)	40									
					Bhagwanpur (A.I.)	30–35									
Mean		9		16		20		21		16		16		20	15%

F–factory; A.I.—Agricultural Inspectors (C.D.S.); A.D.A.—Assistant Director of Agriculture.
Figures within brackets denote the number of replies received on the questionnaire issued from the Sugarcane Research Institute, Bihar, Pusa,

THE 'JHINDRA'—A NOTEWORTHY IMPLEMENT FROM THE PUNJAB

THE 'Jhindra' is a hand-operated implement widely used in the Punjab and in some of the western districts of Uttar Pradesh bordering the Punjab, for forming bunds in fields for irrigation and for laying out fields into plots and sub-plots. In Madras and in certain parts of Uttar Pradesh bullock-drawn bund-formers are used for making bunds. Although undoubtedly these implements give a greater outturn per hour than the Jhindra, they suffer from one disadvantage in that, where bunds cross each other the bund laid first is gathered up in forming the cross bund and such crossings have to be hand-dressed subsequently. For this reason these bund-formers are more commonly used for making straight parallel bunds for sowing row crops like cotton. In the Punjab implement, the bunds laid first are not disturbed by cross bunding operation.

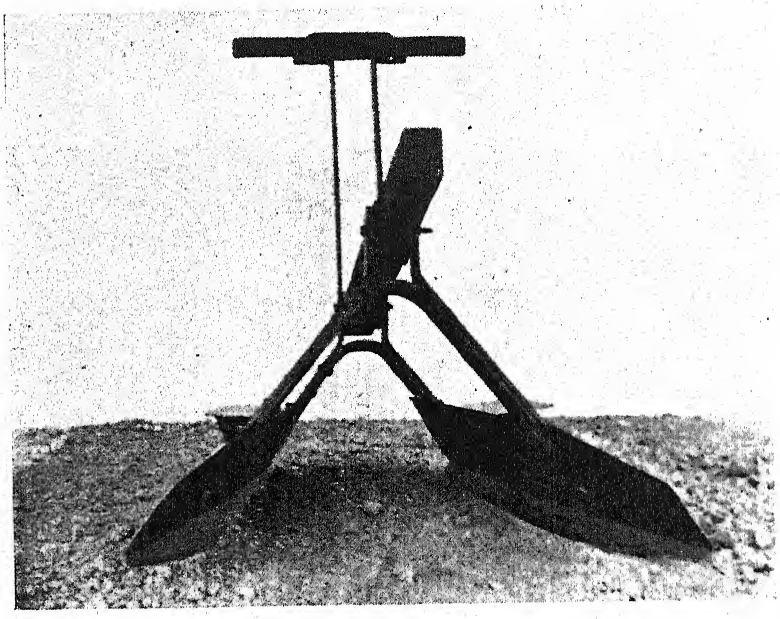


FIG. 1. The Madras Bund Former.

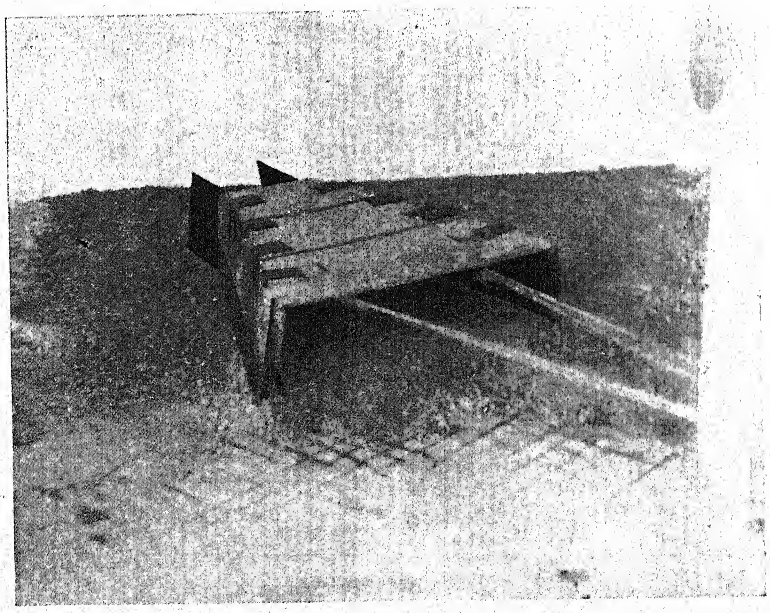


FIG. 2. The U. P. Bund Former.

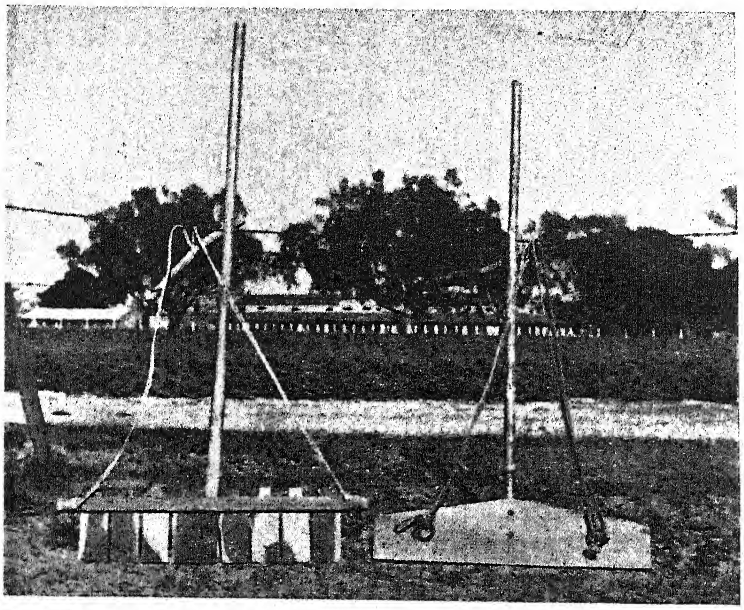


FIG. 3. Two types of "Jhindras".

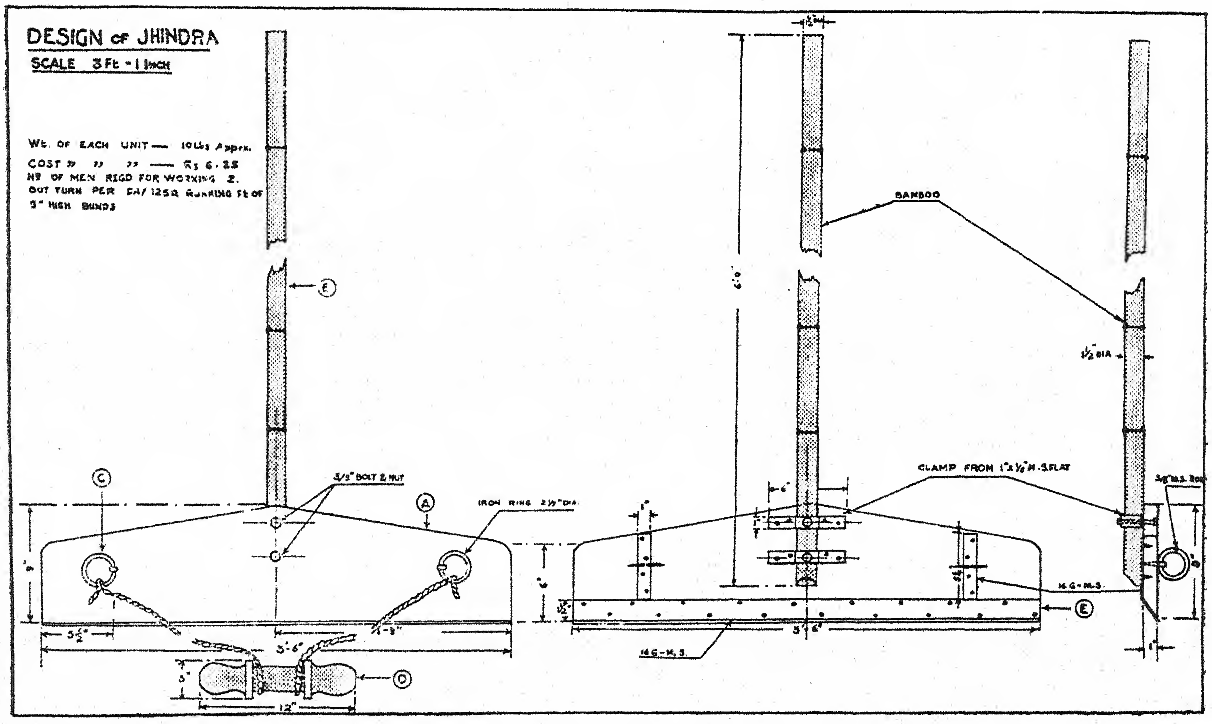


FIG. 4.

The bund-former of the type used in Madras (fig. 1) is made of iron and costs approximately Rs. 30/- each, while the type used in Uttar Pradesh (fig. 2) is made of wood and costs slightly less. No hand-operated implement has been reported to be in use in any other part of India for making bunds. In most States this work is done by manual labour with the aid of spades or "Phawras". This undoubtedly is a slow, laborious and consequently an expensive process.

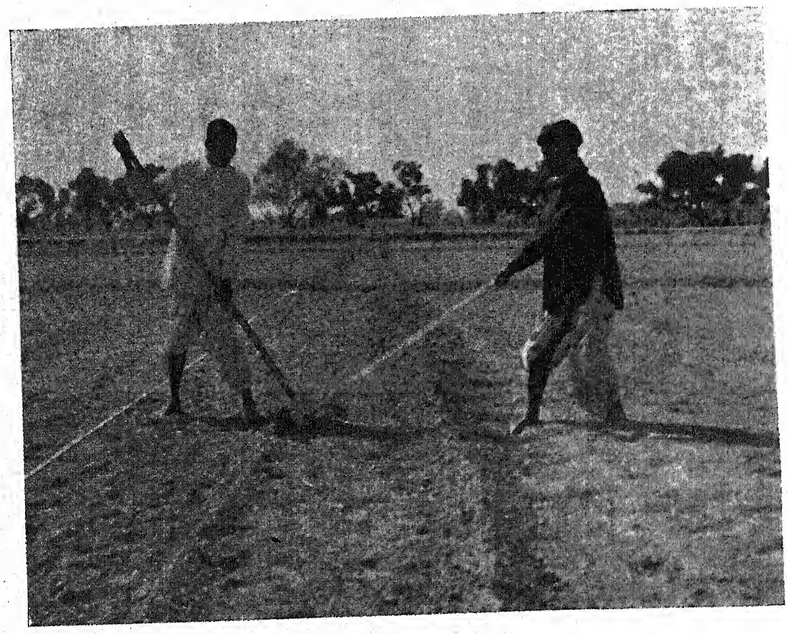


FIG. 5. Bunds being formed with a "Jhindra".

The Jhindras used in various parts of the Punjab (fig. 3) differ slightly in size and in details of construction. The cheapest and simplest model (fig. 4) consists of a wooden plank 'A' $3\frac{1}{2}$ ft. long, 9 inches wide in the middle and tapering to a width of 6 inches towards either end. A 6 ft. long handle 'B' made of bamboo is fixed to its back along the centre line at right angles to the length. The two ends of a rope about 12 ft. long are tied to two iron rings 'C' fitted to the face of the board and a short wooden handle 'D' is tied to the middle of this rope. The bottom of the board is levelled from the back to form an edge and this edge is reinforced with an iron strip 'E' $1\frac{1}{2}$ inches wide, 1/8 inch thick and projecting about 3/16 inch beyond the edge of the board. The implement weighs about 10 lbs. and can be made by any village carpenter and blacksmith. The cost of manufacture would be approximately Rs. 6·25.

The seed bed should be first prepared and then lines along which bunds are required marked. The implement is operated (fig. 5) by two men standing on either side of the line. One man holding the bamboo handle presses the scraping edge of the board into the soil about 2 ft. away from the centre line of the bund, while the other holding the shorter handle fixed to the rope pulls the board towards himself. The implement is lifted up when it reaches the bund line and the soil that is gathered by it is left along the line. The implement is then shifted to its next position down the line at a distance equal to its length and the operation is repeated. When the men reach the end of the line they change positions and repeat the operation in the opposite direction, gathering soil from the other side of the line and laying it along the half bund already formed.

Six numbers of these implements were manufactured and tested at the Indian Institute of Sugarcane Research, Lucknow. It was found that on a well prepared seed bed a bund 9″ high can be formed by working the implement once up and once down a line and that two men can with the aid of this implement lay 1,250 running feet of 9″ high bunds per hour. Higher bunds can be raised if so desired by repeating the operation.

It has, however, to be pointed out that for the efficient working of this implement, the seed bed should be thoroughly prepared and in excellent tilth. Needless to say, the implement has no use in stiff clays which remain cloddy even after the best efforts.

The Jhindra is likely to be of special interest to research stations where the laying out of fields for experimental purposes calls for the making of a large number of bunds. (R. G. MENON, Indian Institute of Sugarcane Research, Lucknow, U. P.)

Research Notes

A Note on the Effect of Mahua Cake on the Chemical Properties of Soil and Yield and Quality of Sugarcane

AMONG the oil cakes used for manurial purposes, the one from the seed of *Mahua* (*Bassia latifolia*) is a cheap source of organic manure as it is practically a refuse material. It has a nitrogen content of 2·5 per cent and P_2O_5 and K_2O contents of 0·8 and 1·9 per cent respectively. It has been tried as a manure for sugarcane as early as 1906 (Leather, 1906). According to Shrikhande (1945) the cake is not suitable as a manure in view of its saponine content which is toxic to soil organisms. In an experiment conducted at the Sugarcane Research Station, Shahjahanpur (U.P.) during 1949-50 it was observed that the values of nitrogen and organic carbon were almost similar under *mahua* cake and groundnut cake treatments. In yield *mahua* cake was found to be at par with groundnut cake, town compost, and castor cake. As regards juice quality the sucrose values under *mahua* cake and groundnut cake were similar.

Experiments were conducted at the Sugarcane Research Station, Jullundur for two years (1952-54) with the variety Co. 312 on the manurial value of *mahua* cake and the preliminary results obtained are reported in this note. The studies were aimed at finding the effect of the cake on the Physico-chemical properties of the soil, nitrogen uptake and on yield and juice quality. In the first year *mahua* cake composted for 120 days with different combinations, (a) press mud (1:1), (b) ammonium sulphate (10:1), (c) farm yard manure (3:1), groundnut cake, and farm yard manure were applied at planting time to supply 100 lb. nitrogen per acre. During the second year, the experiment was modified and *mahua* cake composted and uncomposted were applied at 100 lb. nitrogen per acre with and without a basal dressing of farmyard manure (50 lb. nitrogen per acre). In 1952-53 the experiment was laid out in a randomised block design where as during the following year a split plot design was adopted.

The treatments were as under:

1952-53:

T_1—Control.
T_2—*Mahua* cake uncomposted.
T_3—*Mahua* cake composted with farmyard manure.
T_4—*Mahua* cake composted with pressmud.
T_5—*Mahua* cake composted with ammonium sulphate.
T_6—Ground nut cake.
T_7—Farmyard manure.

1953-54:

A. *Without basal dressing*

T_1—Control.
T_2—100 lb. nitrogen applied in *mahua* cake uncomposted.
T_3—100 lb. nitrogen applied in *mahua* cake composted.

B. *With basal dressing*

T_1—Control.
T_2—100 lb. nitrogen applied in *mahua* cake uncomposted.
T_3—100 lb. nitrogen applied in *mahua* cake composted.

Soil was analysed periodically for nitrate nitrogen, total nitrogen and organic carbon. The yield and juice quality data were recorded in November-December in both the years.

Soil analysis carried out at two depths 0-6″ and 6-12″ indicated that the nitrate nitrogen content during the earlier stages was more in the top 6″ as compared to the next 6″ but the differences narrowed down with the advance of the season. The nitrate nitrogen content was maximum during July after which it tended to decline. In July *mahua* cake uncomposted recorded the highest total nitrogen content followed by *mahua* cake composted with ammonium sulphate as well as farmyard manure. As a matter of fact uncomposted *mahua* cake maintained its higher nitrogen status throughout the life cycle of the crop during the year 1952-53.

As regards organic content of the soil, during 1952-53 the uncomposted *mahua* cake added comparatively higher amounts of organic carbon to the soil than composted one. The C/N ratio recorded an increase with the advance in the season under all the treatments. During the second year of the experiment the differences in the values of nitrate nitrogen, total nitrogen, and organic carbon under *mahua* cake uncomposted and *mahua* cake composted, though in favour of the former treatment, were negligible. The soil analysis for July is given in Table I. The nitrogen content of the leaf was also estimated and it followed the same trend as nitrate nitrogen in the soil, being highest in July and declining progressively with the age of the crop. Of the treatments *mahua* cake uncomposted recorded the highest leaf nitrogen (1·375 per cent) while such values under control and *mahua* cake composted were similar being 1·359 per cent.

As regards yield, the treatment with uncomposted *mahua* cake was the best followed by *mahua* cake composted with farmyard manure. The increase in yield over the control in the first case was of the order of 80·6 maunds. This was, however, not significant.

TABLE I

Showing data on soil analysis yield and juice quality

Treatment	Nitrate nitrogen per cent		Organic carbon per cent		Total nitrogen per cent		C/N ratio		Yield per acre mds.	Juice quality	
	0–6″	6–12″	0–6″	6–12″	0–6″	6–12″	0–6″	6–12″		Sucrose Per cent	Purity co-efficient
					1952–53						
T_1	0·080	0·043	0·327	0·192	0·0642	0·0343	5·09	5·60	683·7	14·2	82·3
T_2	0·195	0·093	0·366	0·210	0·0672	0·0457	5·45	4·40	764·3	13·6	81·9
T_3	0·129	0·060	0·358	0·159	0·0651	0·0415	5·50	3·83	748·8	12·9	81·2
T_4	0·190	0·064	0·324	0·210	0·0611	0·0394	5·30	5·10	681·5	13·5	82·2
T_5	0·155	0·063	0·407	0·135	0·0691	0·0392	5·89	3·45	698·7	13·6	81·4
T_6	0·155	0·101	0·292	0·141	0·0597	0·0308	4·07	4·58	717·3	13·3	81·4
T_7	0·127	0·060	0·324	0·183	0·0617	0·0308	4·79	5·94	694·0	13·4	82·6
					1953–54						
A T_1	0·035	0·005	0·210	0·066	0·0343	0.0273	6·12	2·42	475·2	13·5	79·4
T_2	0·008	0·010	0·210	0·138	0·0427	0.0301	4·92	4·58	467·7	13·3	79·6
T_3	Traces	0·003	0·228	0·090	0·0427	0.0315	5·34	2·86	455·7	13·5	80·3
B T_1	0·043	0·015	0·192	0·108	0·0434	0.0315	4·42	3·54	449·7	13·1	78·4
T_2	0·086	0·018	0·228	0·084	0·0392	0.0248	5·07	3·37	468·0	12·6	76·3
T_3	0·040	0·008	0·198	0·090	0·0357	0.0266	5·55	3·38	453·0	13·3	80·1

In 1953-54 uncomposted *mahua* cake again recorded higher yield over control but the increase was small. Application of a basal dressing of farmyard manure did not influence the cane yield. The differences in yield were non-significant.

It would appear from the above study that the application of *mahua* cake results in an improvement, though little, in the nitrate nitrogen, total nitrogen and organic carbon status of the soil. There is also an increase in yield and juice quality which is superior to that obtained by application of groundnut cake.

ACKNOWLEDGMENTS

The authors' thanks are due to the Government of Punjab and Indian Central Sugarcane Committee who are jointly financing the scheme of Sugarcane Research in the Punjab. (P. S. GILL and HARDIAL SINGH, Sugarcane Research Station, Jullundur, Punjab).

REFERENCES

A.O.A.C. (1945). Official and Tentative methods of Analysis (Washington, D.C., U.S.A.).
Mukerji, B. K. (1950). Annual Report of Sugarcane Research Work, U.P.
Leather (1906). *Agri. Journ. India*, **I.**
Shrikhande (1945). *Indian Sugar*, **I.**

A Note on Nodal Floral Buds in Erianthus Munja Roxb

VIJAYASARADHY *et al.* (1952) reported the occurrence of floral buds on nodes in *Narenga porphyrocoma* (Hance) Bor. The presence of nodal floral buds have now been noticed in one species of *Erianthus*. In *Erianthus munja* the aerial culms are flowering in nature (Hole, 1911). In a clump, flowering culms are those that are formed during the early stages and the non-flowering are those formed during the end of the growth period. The latter flower in the succeeding year. The observations recorded in this paper are from a crop of *E. munja* left over for two to three years. Stalks of one of the forms of *Erianthus munja* in flower showed on examination floral shoots in the axils of the second, third and fourth leaves from the top in successive stages of development, the fourth having only a rudimentary inflorescence. The figure illustrates these axillary inflorescences.

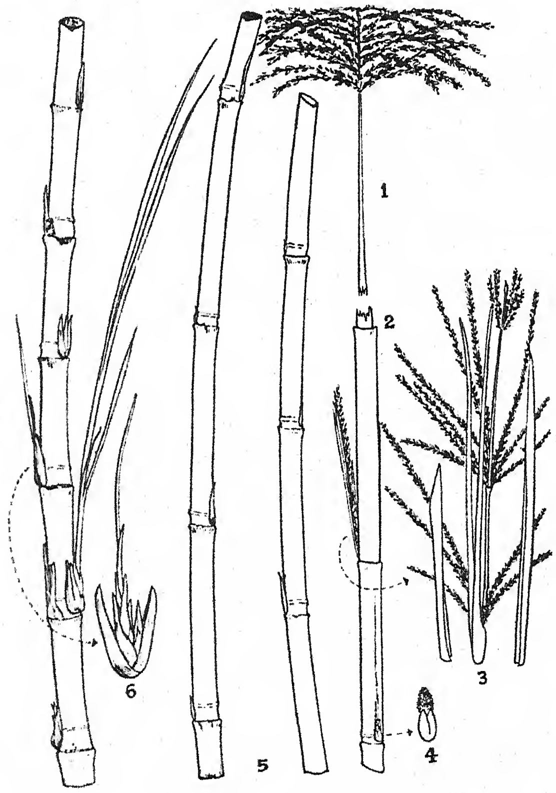


FIG. Flowering stalk (in parts) of *Erianthus munja* showing the relative position of axillary floral and axillary vegetative shoots and the small inflorescences formed.

1. Floral axils and basal portion of the main inflorescence;
2. Topmost node, devoid of bud;
3. Floral shoot with elongated bud-scale on the second node from top;
4. Inflorescence primordium on third node from top;
5. Dormant buds in the mid-portion of the stalk, and
6. Vegetative shoots on the lower buds of the stalk.

In a few cases, one of the top axillary buds, apart from the terminal panicle appeared to have given rise to a vegetative shoot, but on dissection, a rudimentary panicle was found encased by the young leaves. The transition from the vegetative condition at the base to the floral condition at the top appears to be gradual. In all cases the mid-portion of the stalk possessed vegetative buds in dormant condition and the buds on the bottom region of the stalk developed into young vegetative shoots.

The clones which showed axillary floral buds and rudimentary inflorescences were SES 190, 193, 219, 221, 228, 240, 257, 265 A and B, 266A and B, 287 and 359. All these have n=30 chromosomes. No other species of *Erianthus* except *E. munja* showed nodal floral buds.

On the basis of this character, Vijayasaradhy *et al.* (1952) suggested that *Narenga porphyrocoma* may be considered as a connecting link between the two tribes *Andropogoneae* and *Maydeae*. Under certain conditions, production of inflorescences from short axillary shoots borne on the top-portion has been observed also in *Saccharum spontaneum* (Panje, 1953). It seems that the propensity of axillary buds to produce inflorescences with or without a short stretch of vegetative growth preceding it is generally prevalent in the sub-tribe as a whole, and plants of the different species either show this character in varying degrees or revert to it under certain conditions.

In the three genera, viz., *Narenga, Erianthus,* and *Saccharum,* a trend from a stage where all the above ground buds are entirely floral as in *Narenga* through *Erianthus* where only the upper buds of the axis are floral (and even in these the immediately lower ones are vegetative to start with), to a condition in which axillary shoots are vegetative as in *Saccharum* is obervable. Within *Saccharum* itself, the progressive transition from floral to vegetative is noticeable as between *S. spontaneum* where cases are met with of axillary shoots from top nodes flowering along with the main stalk, and *S. officinarum* in which floral differentiation is confined exclusively to the terminal buds and its onset markedly delayed.

Acknowledgment

I am indebted to Shri R. R. Panje, Botanist, for his guidance and help. My thanks are also due to Dr. N. R. Bhat, Director, Sugarcane Breeding Institute, for his encouragement. (P. R. Jagadees Prasad, Sugarcane Breeding Institute, Coimbatore, Madras).

References

Vijayasaradhy, M., Thuljaram Rao, J. and Narasimhan, R. (1952). Nodal buds of *Narenga porphyrocoma* (Hance) Bor. *Curr. Sci.*, **21:** 75.
Hole, R. S. (1911). On Some Indian Forest Grasses and oecology. *Ind. Forest Mem. Forest Bot. Ser.*, **I**, Part I: 126.
Panje, R. R. (1933). Annual Report of Sugarcane Breeding Institute, Coimbatore, 1952-53: 89.

Preliminary Studies on the Influence of Shade with Particular Reference to Age of Crop, on Cane Juice Quality

Herret *et al.* (1927), Martin *et al.* (1933), Das (1935), Borden (1936, 1941), Clements (1940) and Dillewijn (1952) reported on the influence of intensity of sunlight and the dominating effect of climate in general, on the growth, yield and juice quality of sugarcane and consequently the sugar output per acre. Direct sunlight is denied to shaded plants and hence the energy needed for photosynthetic activity is apparently lowered resulting in poorer accumulation of sucrose. A preliminary study to investigate the differential effect, if any, of shading sugarcane at different ages was conducted at the Sugarcane Research Station, Anakapalle during 1958 and the results are furnished in this note.

Single budded setts were planted in pots on 26th March, 1958. Only one shoot was allowed to come up. Tillers were nipped in the bud. There were two shade treatments viz., shading for six hours each day for four months from (1) the beginning of the third to the end of sixth and (2) from the beginning of the fifth to the end of the eighth month respectively, after planting. Shade was provided in continuation of the night by putting up a canopy of bamboo mats on a scaffold over the pots. Variety was Co. 419.

There were two manurial treatments viz., 100 lbs. N and 200 lbs. N per acre. The control pots were unshaded.

The plants were harvested in December and juice analysed for sucrose and purity with the following results.

The data presented above indicate that shading adversely affects the sucrose content of juices; and more so when the age of the crop is higher. Heavily manured plants (200 lbs. N per acre) appear to reflect the adverse influence of shading to a more marked degree than the plants that received normal quantity of fertilizer (100 lbs. N per acre). Further studies are being planned on the subject at this research Station.

Studies on the effect of shading sugarcane at different periods of growth. Juice quality in December at the age of about 9 months (Variety Co.419).

Particulars of shade treatment	100 lbs. N per acre				200 lbs. N per acre			
	Brix	Sucrose (per cent)	Coeff. of purity	Reduction in sucrose content due to shading (per cent)	Brix	Sucrose (per cent)	Coeff. of purity	Reduction in sucrose content due to shading (per cent)
A. Control (no shading) ..	18·69	17·06	91·28	..	18·07	15·78	87·83	..
B. Shading for 4 months for 6 hours daily from the third to end of sixth month after planting ..	18·69	16·45	88·01	3·58	17·00	14·54	85·53	7·86
C. Shading for 4 months for 6 hours daily from the 5th to end of 8th month after planting ..	17·09	14·52	84·96	14·89	14·75	11·87	80·47	24·78

Acknowledgment

Thanks are due to the Sugarcane Specialist for affording facilities and to the Indian Central Sugarcane Committee who are partly financing the research scheme at this station.—(M. Lakshmikantham and K. K. Prasada Rao, Sugarcane Research Station, Anakapalle, Andhra Pradesh).

REFERENCES

Borden, R. J. (1936). Cane growth studies. The dominating effect of climate. *Haw. Plant Rec.*, **40**: 143-56.

———— (1941). Cane growth studies. Factors which influence yields and composition of sugarcane. *Haw. Plant. Rec.*, **45**: 241-63.

Clements, H. F. (1940). Integration of climatic and physiologic factors with reference to the production of sugarcane. *Haw. Plant Rec.*, **44**: 201-33.

Das, U. K. (1935). A pot experiment with cane growth in the same soil but under different climatic conditions. *Haw. Plant. Rec.*, **39**: 26-29.

Dillewijn, C. Van. (1952). Botany of Sugarcane. Chronica Botanica Co.

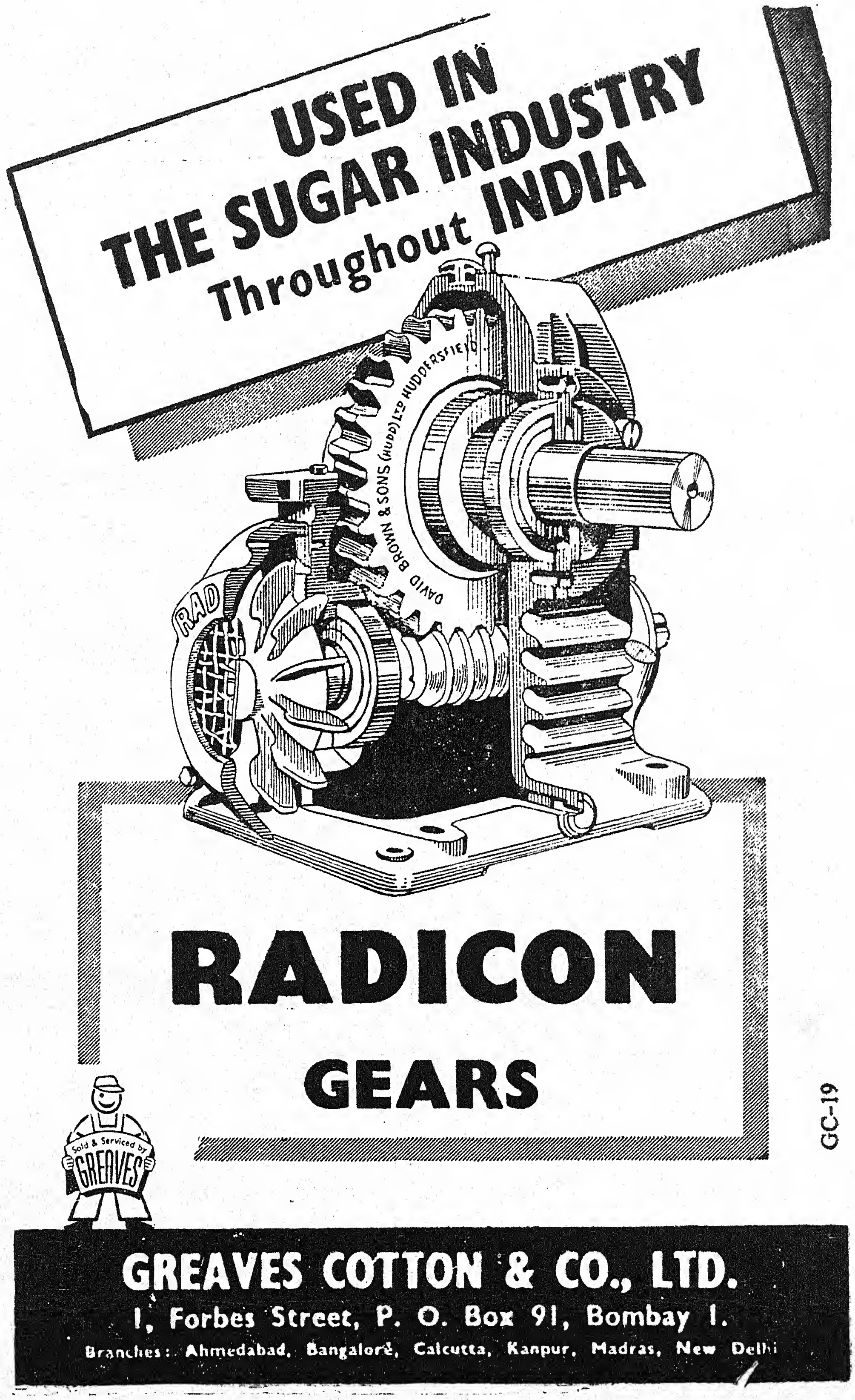
Martin, S. P. and Eckart, R. C. (1933). The effect of various intensities of light on the growth of the H. 109 Variety of sugarcane. *Haw. Plant Rec.*, **37**: 53-66. (Original not seen) quoted by Dillewijn.

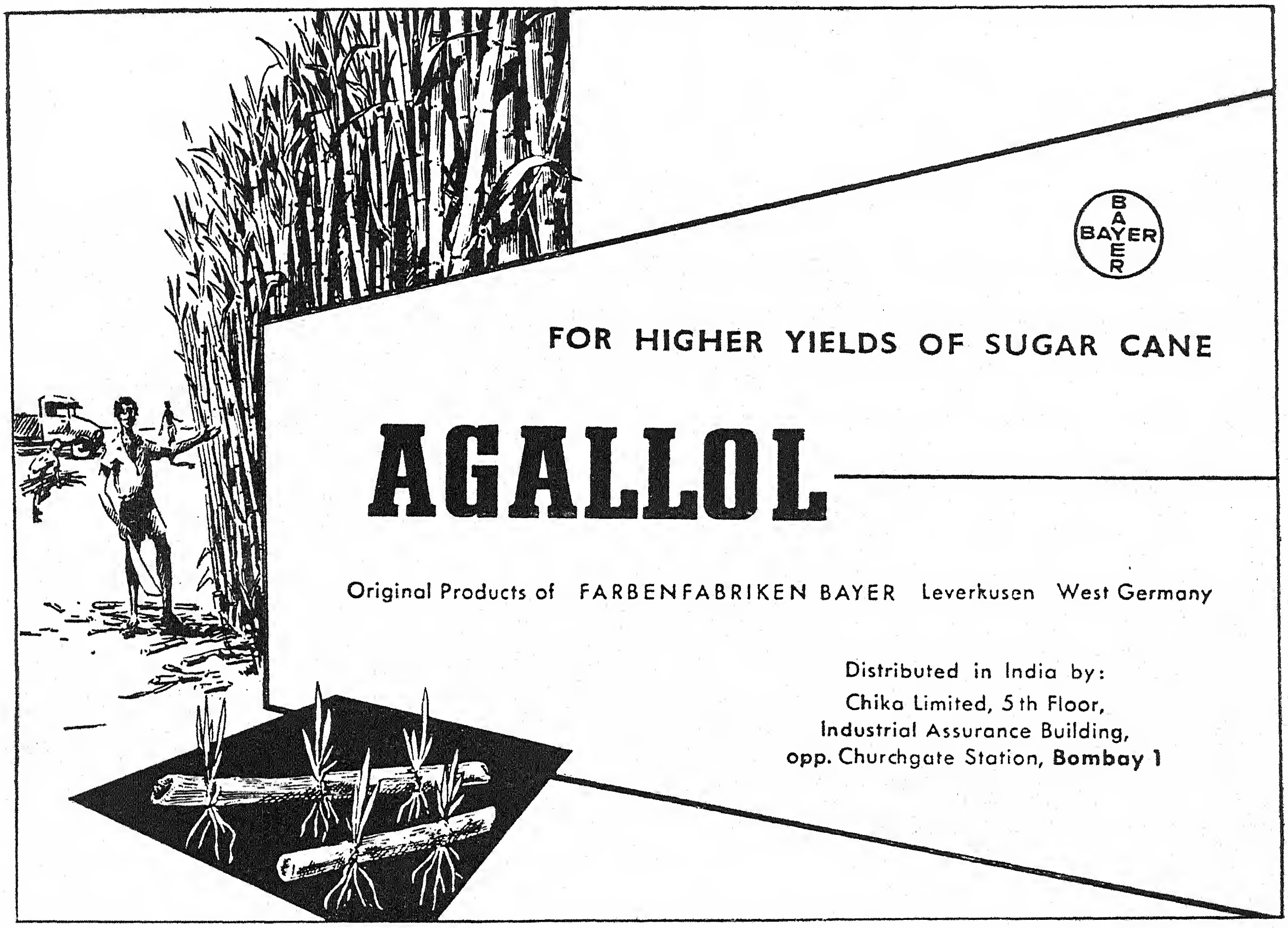
Verret, J. A. and Mclennan, R. H. (1927). The effect of sunlight on cane growth. *Haw. Plant Rec.*, **31**: 116-21. (Original not seen) quoted by Dillewijn.

SUGARCANE RESEARCH IN INDIA DURING 1929-54

The Ad-Hoc Expert Sub-Committee of the Indian Central Sugarcane Committee consisting of Sarvashri Lal Singh, N. L. Dutt and K. L. Khanna, after visiting a number of sugarcane research stations in operation in the States and looking through voluminous data collected under the sugarcane research and development schemes, have prepared the Resume of Sugarcane Research in India during 1929-54. It contains in the form of notes the recommendations that have emerged as a result of the research work done under Sugarcane Research Schemes both at the Central and States Institutes, on different aspects of sugarcane research based on the different aspects of sugarcane cultivation. These notes have been arranged accordingly as different chapters e.g., Sugarcane Agronomy, Sugarcane Physiology, Soil Studies etc.

The Resume presents not only an All-India picture but important details of studies carried out in the States are also included. The Resume under the title of 'Review on Sugarcane Research in India during 1929-54' appeared in a serial form in the Indian Journal of Sugarcane Research & Development and has now been compiled as a single book with graphic and illustrated cover in coloured design. The price per copy (exclusive of postage) is Rs. 5/-...... and is available from the Secretary, Indian Central Sugarcane Committee, 19-20, Rohtak Road, New Delhi-5.


USED IN
THE SUGAR INDUSTRY
Throughout INDIA
DAVID BROWN & SONS (HUDD) LTD HUDDERSFIELD
RAD
RADICON
GEARS
Sold & Serviced by
GREAVES
GC-19
GREAVES COTTON & CO., LTD.
1, Forbes Street, P. O. Box 91, Bombay 1.
Branches: Ahmedabad, Bangalore, Calcutta, Kanpur, Madras, New Delhi


BAYER
FOR HIGHER YIELDS OF SUGAR CANE
AGALLOL
Original Products of FARBENFABRIKEN BAYER Leverkusen West Germany
Distributed in India by:
Chika Limited, 5 th Floor,
Industrial Assurance Building,
opp. Churchgate Station, Bombay 1

INDIAN COUNCIL OF AGRICULTURAL RESEARCH

Utilization of the services of retired scientists in the field of agriculture, animal husbandry and allied sciences

1. The existing rules regarding superannuation sometimes put an abrupt end of the research work of any active scientist or, at any rate, make the continuation of such work extremely difficult as a result of which the talent of a good number of scientists who are physically fit and mentally alert is wasted after retirement for lack of opportunities to pursue work in their fields of specialization. In order that the experience and talent of such scientists as have finished with their active professional career is not wasted, the Indian Council of Agricultural Research has decided to initiate, with effect from the 1st April, 1960, a scheme for the utilization of the services of retired scientists in the field of agriculture, animal husbandry and allied sciences.

2. Under the scheme retired/retiring scientists of established reputation who are still active in research will be enabled to continue their researches with suitable financial assistance from the Indian Council of Agricultural Research. The retired or retiring scientist should try to secure sponsoring Institution (which may be one from which he has retired or a different one) which would provide him necessary facilities for continuing his work e.g. access to the laboratory and library, accommodation for work etc. Failing this, the scientist may apply to the Indian Council of Agricultural Research and the Council will try to place him in a suitable Institution. The choice of the Institution at which the retired scientist would continue his researches will be left to the scientist himself but such Institution should be one acceptable to the Council. The retired or retiring scientist (within a year of his retirement) will submit to the Council, an outline scheme of research which he intends to undertake after retirement. In doing so, he will clearly give an account of the research work done by him during the five years preceding the date of his retirement or application whichever is later.

3. An annual allowance not exceeding Rs. 6,000/- will be provided to the retired scientist himself, if asked for by him, and a grant ordinarily not exceeding Rs. 4,000/- to cover the cost of one research assistant and other expenses as may be decided by the Council. The amount of the grant may be increased in exceptional cases where the investigations involve field work necessitating undertaking of tours or where costly equipment/apparatus have to be purchased.

4. The allowances and grants to the scientists under the scheme will be provided, in the first instance, for a period of three years only. As usual, annual progress reports shall be submitted to the Council by the scientist. Where the retired scientist would like the grant to be renewed, he will have to submit a year in advance of the termination of the first sanction, an application to that effect indicating the progress made under the scheme and the programme proposed to be followed during subsequent years. The allowances and grants to the retired scientists will be payable on a quarterly basis through the Institution to which the retired scientist is attached.

All applications for grant under the scheme should be submitted to the Council in the prescribed proforma which can be obtained, free of cost, from the Secretary, Indian Council of Agricultural Research, Krishi Bhavan, Dr. Rajendra Prasad Road, New Delhi.

STUDIES ON CROP-WEATHER RELATIONSHIP-II. THE INFLUENCE OF WEEKLY RAINFALL ON SUGARCANE YIELDS AT THE GOVERNMENT EXPERIMENTAL FARM, PUSA, BIHAR

By

R. C. Acharya, M. N. Alam, A. B. B. Sinha and K. L. Khanna

(Sugarcane Research Institute, Pusa, Bihar)

Introduction

BIHAR is the second largest cane growing State in India. The important sugarcane growing districts are situated in North Bihar, which has a network of 24 sugar factories. The climate of this region varies from humid to semiarid. The preparatory tillage and planting are generally done during the months January to March, but about 30-33 per cent of the total acreage is also planted during October-November. The germination is complete by the end of April when the young plants have to face the severe summer drought. Grand growth period starts with the onset of monsoon and lasts upto the end of September. The crop becomes mature by December. The juice quality gradually increases, reaching the peak by the end of February or first fortnight of March, when on account of dry westerly winds the soil moisture is reduced and the quality of the crop starts to show a declining trend.

Pusa is a representative Farm of North Bihar where the Sugarcane Research Institute of the State is situated. The Research Station dates back to 1936 when the Indian Agricultural Research Institute was shifted from this place to New Pusa at Delhi. The soil of the farm is calcareous with pH ranging between 8·0 and 8·5.

A series of 21 years' data on sugarcane (from 1936-37 to 1956-57) being the average acre-yield of Pusa Farm was available which form the basis of this paper, embodying results of an investigation on the influence of quantity and distribution of rainfall on the yield of sugarcane. During these years there had been changes in the varieties grown at the Farm but the manurial and cultural practices were practically the same. As quite a large number of varieties with varying degrees of yield potentials are grown in the Farm, changes in the varietal composition did not affect materially its average acre-yields. In the first article of the series Khanna and Sahgal (1957) reported the results of a similar investigation utilising eighteen years' data on sugarcane at Daudpur Farm.

Methods and Materials

Fisher (1924), while examining the effect of rainfall on the annual yields on wheat on 13 Broad balk plots which had received continuous manuring over the period 1852-1918, developed a special technique for estimating the linear regression of annual yields on rainfall throughout the year and the response curves showing the expected change in yield from an additional inch of rainfall above the average falling at any time of the year. The same method of analysis was applied by Kalamkar (1933) to the continuous experiments with mangolds at Rothamstead and Kalamkar and Satokopan (1940) to the cotton yield data from the Government Farm at Akola and Jalgaon. Nair and Bose (1945) generalised the above method when the influence of more than one meteorological factor is to be studied. This specialised method has been adopted in the analysis of the data pertaining to the present investigation. The method of examining the influence of one meteorological factor is given below.

The linear regression equation of the yield of the crop on the meteorological factor may be written as

$$y=C+\sum_{i=1}^{n} a_i m_i \qquad (1)$$

where m_1, m_2......, m_n are the measurements of the meteorological factor in different intervals of time. If the sub-divisions of time were made infinitely small, the linear regression function may be replaced by a regression integral of the form $y=C+\int_o^T am\,dt$ (2)

where, m dt is the effect of the meteorological factor in the element of time dt, the integral being taken over the whole period.

If $T_o, T_1, \ldots \ldots T_q$ be series of orthogonal polynomial functions of time such that

$$\int_o^T T_r\, T_s\, dt = o \ (r \neq s); \quad \int_o^T T_r^2\, dt = 1,$$

then we may represent the distribution of the meteorological factor as a time series in orthogonal polynomial

$$m = \rho_o T_o + \rho_1 T_1 + \ldots \ldots + \rho_q T_q \qquad (3)$$

The regression values $a_1, a_2 \ldots \ldots a_n$ in (1) may be expected to lie on a continuous time curve so that we may express the regression function in (2) in the form

$$a = \alpha_o T_o + \alpha_1 T_1 + \ldots \ldots \alpha_q T_q \qquad (4)$$

Now, using the relations (3) and (4), relation (2) stands as

$$y = C + \rho_1 \alpha_1 + \rho_2 \alpha_2 + \ldots \ldots + \rho_q \alpha_q \qquad (5)$$

Now, the values of $\rho_1, \rho_2 \ldots \ldots \rho_q$ may be obtained from each year by fitting orthogonal polynomial to meteorological data and then by correlating the series with the corresponding yields of the crop we can get the value of α_i (i=1 to q) as partial regression coefficients using relation (5).

By substituting these values in (4) we get values of $\alpha_1, \alpha_2 \ldots \ldots, \alpha_q$ which will give us the effect of change in the meteorological factor at any point of time in the season on the yield of crop.

For studying the effect of rainfall on the yield of sugarcane the period from 1st January to 7th October has been considered. The period beyond the first week of October has been left out of consideration because (i) the crop completes its growth by this time, (ii) the monsoons generally end at this time of the year in this region and (iii) it is the termination of the 9th period out of 12 periods into which the year has been divided by the Indian Meteorological Department. This period has been divided into 40 weeks. The total weekly rainfall figures have been computed from the daily rainfall records in respect of each year under consideration.

Analytical Results

An orthogonal polynomial of the fifth degree was fitted to the weekly rainfall figures for each year by Fisher's summation method and the six constants, a′, b′, c′, d′, e′ and f′ were obtained. The annual acre-yields of sugarcane at Pusa Farm along with these rainfall distribution constants obtained for each year have been shown in Table I. The acre-yields have varied from 201 to 457 maunds during this period, the coefficient of variation being 19·7.

TABLE I

Acre-yield and rainfall distribution constants

Crop Season	Yield in maunds.	a′	b′	c′	d′	e′	f′
1936-37	273	1·0215	0·5054	0·0174	−0·1146	−0·0162	0·0504
1937-38	423	1·6512	0·9181	0·2509	−0·0114	−0·0416	0·0627
1938-39	443	1·4952	0·5868	−0·2034	−0·3617	−0·1145	0·0688
1939-40	358	0·9822	0·3788	−0·1228	−0·2267	−0·0745	0·0778
1940-41	352	0·8810	0·3499	−0·0461	−0·0821	−0·1149	0·0097
1941-42	381	1·2035	0·6128	0·0320	−0·1961	−0·1564	−0·0942
1942-43	423	1·1345	0·5878	0·2642	0·0623	0·0045	0·0530
1943-44	363	0·9612	0·4398	0·0608	−0·0677	−0·0225	0·0184
1944-45	379	0·9847	0·4519	0·0603	−0·0641	−0·0671	0·0067
1945-46	269	0·8738	0·3850	0·1436	−0·0795	0·0113	−0·0504
1946-47	278	1·1908	0·6176	0·1022	−0·0154	0·0910	0·1808
1947-48	201	0·9943	0·4924	0·0068	−0·1691	−0·0779	0·0178
1948-49	320	1·0957	0·5004	−0·0818	−0·2581	−0·0881	0·0734
1949-50	438	1·5130	0·5350	−0·0774	−0·2415	−0·1299	0·0072
1950-51	446	0·9577	0·3779	−0·1185	−0·1931	−0·0429	0·0391
1951-52	457	0·6745	0·2906	−0·0366	−0·1239	−0·0359	0·0456
1952-53	421	1·1908	0·5346	−0·0500	−0·1554	−0·0094	0·0348
1953-54	331	1·1907	0·4422	−0·0766	−0·2548	−0·0584	0·0788
1954-55	414	1·1807	0·5519	−0·0077	−0·2206	−0·1022	0·0227
1955-56	321	1·4152	0·6544	−0·0646	−0·3011	−0·1535	0·0328
1956-57	294	1·2600	0·5908	0·0442	−0·1012	−0·0048	0·0140
Mean	361	1·1358	0·5146	0·0090	−0·1527	−0·0563	0·0357

The slow secular changes in the annual yields as a result of factors other than weather, viz., deterioration of the soil, influence of weeds etc., as also in the rainfall distribution constants has been examined by

fitting 5th degree polynomials to these data before investigating the rainfall effect. The values of the transformed coordinates (x′) obtained by multiplying the constants of polynomials fitted to the yield data and the rainfall distribution constants (b′, c′,...... f′) by factors of the form,

$$\sqrt{\frac{(2r+1)\ 21\ldots\ldots(21+r)}{20\ldots\ldots(21-r)}} \qquad (r=1 \text{ to } 5)$$

have been presented in Table II with their standard residues. In an unchanging series the values of x_2', x_3',......x_6' vary about zero in an approximately normal distribution (Fisher).

TABLE II

Secular changes in yields and rainfall constants

	Yield	a′	b′	c′	d′	e′	f′
Mean	361·14	1·1358	0·5146	0·0090	−0·1527	−0·0563	0·0357
x'_2	−7·17	−0·0108	−0·0790	−0·1431	−0·1290	−0·0108	−0·0017
x'_3	4·17	0·4480	0·2494	−0·0473	−0·0886	−0·0295	0·0165
x'_4	−46·84	0·0032	0·0486	0·1425	0·0809	−0·0291	−0·0680
x'_5	−199·08	−0·0133	0·1732	0·1599	0·0666	0·1466	0·0311
x'_6	45·43	0·3537	0·5352	−0·2316	−0·0791	0·1786	0·0376
S.R.	61·84	0·2326	0·0175	0·1000	0·1090	0·0387	0·0572

It is seen that acre-yields of sugarcane at Pusa Farm have exhibited during these 21 years a downward trend as indicated by its value of x'_5 which is negative and significant. The mean weekly rainfall did not show any change during this period as all the values of x′ for a′ are nonsignificant. Similarly, no significant changes have occurred in the rainfall constants c′, d′ and f′ but b′ has shown very significant changes as all the values of x′ for this constant are significant. Slight upward changes are also noticed in e′ as indicated by the significant values of x'_3, and x'_4.

Table III gives the estimates of correlation coefficients between yield in one hand and rainfall distribution constants on the other. In column 3 of this table has been given the values of correlation coefficients after eliminating the secular trends.

TABLE III

Values of correlation coefficients between yield and rainfall constants with and without elimination of trend

Correlation between	Without trend elimination	After trend elimination
$r_{ya'}$	0·6557	0·2366
$r_{yb'}$	0·0482	0·2184
$r_{yc'}$	−0·1505	0·2432
$r_{yd'}$	−0·1026	0·2771
$r_{ye'}$	−0·2113	0·0709
$r_{yf'}$	−0·0393	−0·1294

It will be seen that the correlation coefficients have changed signs in three cases and the values have increased in some cases. A partial regression equation was fitted to the data of yield deviations as dependent variate and similar deviations of rainfall distribution constants as independent variates, the equation to which is as follows:—

$$Y=184{\cdot}6626\ a'-31{\cdot}3975\ b'-593{\cdot}6120\ c'+929{\cdot}3651\ d'-192{\cdot}1298\ e'-371{\cdot}8349\ f'$$

The value of the Multiple Correlation Coefficient (R) has worked out to 0·5940 which is non-significant as will be evident from Table IV of analysis of variance partitioning the total sum of squares.

TABLE IV

Analysis of variance

Variation due to	D.F.	S.S.	M.S.	F
Total	20	57,363·63	..	..
Regression	6	20,256·47	3,376·08	1·27
Deviation	14	37,107·16	2,650·51	

The expected values of yields for the various seasons were then calculated with the help of the above regression equation and have been shown with the observed yields in Fig. 1. It is seen that the differences between the calculated and observed yields are very wide in 1939, 1941, 1945, 1946, 1948, 1949, 1952, 1953, 1955 and 1956.

The values of the partial regression coefficients have been divided by

$$\frac{(r!)^2}{(2r)!}n\,(n+1)\ \ldots\ldots\ (n+r)\quad (r=0 \text{ to } 5)$$

to give the six coefficients in the equation to the Response Curve as under

$$a=A+B\,\varepsilon_1+C\,\varepsilon_2+D\,\varepsilon_3+E\,\varepsilon_4+F\,\varepsilon_5$$

where ε's are polynomials in t (time). The Response Curve showing the expected average effect in maunds per acre corresponding to an additional inch of rain above the average at any point of time during the period considered has been plotted in Fig. 2.

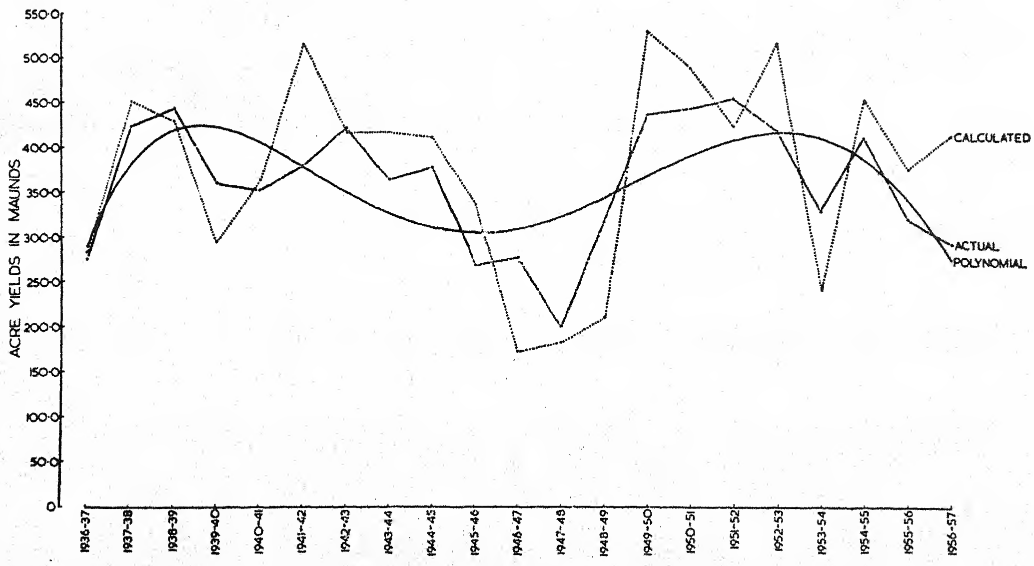


FIG. 1. Calculated & actual values of acre yields of sugarcane at Pusa Farm

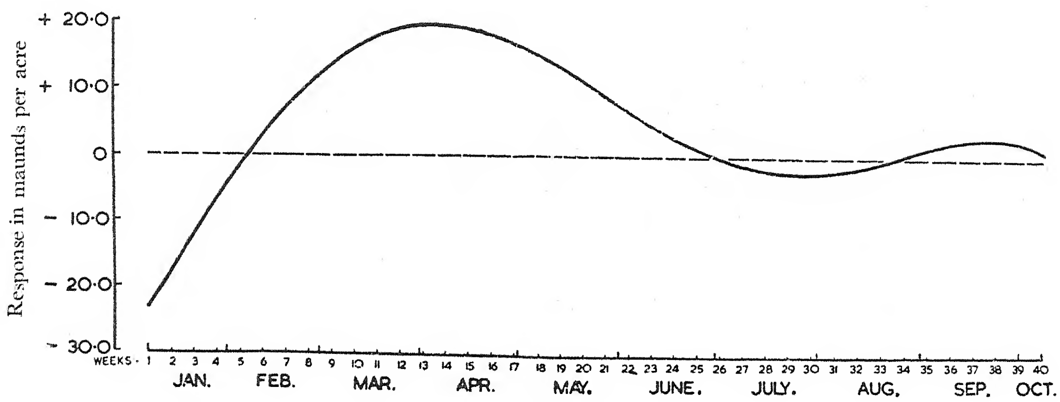


Fig. 2. Response Curve

Discussion

The special method of analysis developed by Fisher has been applied in investigating the influence of rainfall on sugarcane yield at Pusa Farm. Orthogonal Polynomials of the 5th degree were fitted to each year's weekly rainfall data from 1st week of January to 1st week of October. The slow secular changes in yields as also in the rainfall distribution constants were eliminated by fitting smooth curves to these data. A partial regression integral was worked out with the series of deviations in yields as dependant variate and similar deviations in the rainfall distribution constants as independent variates. The Multiple Correlation Coefficient has failed to attain the level of significance and thus the influence of rainfall on sugarcane yields could not be clearly established with the available data, probably because of small number of seasons considered. The percentage of total variation in yields during this period accounted for by the regression is 35·31.

From the partial regression coefficients, response curve representing the change in yield expected as a result of an additional inch of rainfall above the average at any point of time considered was worked out which shows that increased precipitation during January and first part of February is highly harmful to sugarcane crop. It may be noted that planting of sugarcane at Pusa Farm is mostly done during this period and consequently increased rain at this time would adversely affect germination. The curve has further revealed that increased rain during July and part of August slightly deteriorates yield. The response curve has brought into lime-light the highly beneficial effect of rainfall during the summer months, viz., March to 1st fortnight of June. This indicates that the average precipitation during this period in this region is quite insufficient for the requirement of the young plants. The slight beneficial effect of rainfall during September cannot be explained because increased rainfall in this month is expected to cause lodging of the crop.

Summary

1. Twentyone years' sugarcance yield and rainfall data (1936-37 to 1956-57) available at the Government Farm at Pusa, Bihar have been analysed to study the influence of rainfall on yield of sugarcane.

2. The influence of rainfall on yield of sugarcane could not be clearly established with the available data, the Multiple Correlation Coefficient being non-significant. 35·31 per cent of the total variation in yields was accounted for by this meteorological factor.

3. Response curve representing the expected change in yields due to an additional inch of rain at any point of time considered was worked out which shows that higher rainfall during January and part of February is harmful to the crop, this being the period when planting of sugarcane is mostly done at this Farm; while increase in rainfall during summer months (March to 1st fortnight of June) is expected to improve considerably the final outturn, thus establishing the need for hot weather irrigation to sugarcane in North Bihar, where the cultivators very seldom apply irrigation to this crop.

Acknowledgment

The work was done as a part of the Sugarcane Research Scheme jointly financed by the State Government and the Indian Central Sugarcane Committee to whom grateful thanks are due.

REFERENCES

Fisher, R. A. (1924). *Phil. Trans. B.*, **213:** 89.
Kalamkar, R. J. (1933). *Jr. Agri. Sci.*, **23:** 571.
———— and Satakopan, V. (1940). *Ind. Jr. Agri. Sci.*, **10:** 960.
Khanna, K. L. and Sehgal, B. R. (1957). *Ind. Jr. Sug. Res. & Dev.*, **1:** 85.
Nair, K. Raghavan and Bose, P. (1945). *Sankhya*, **7:** 213.

ON THE UTILITY OF TRASH MULCH IN SUGARCANE FIELDS

By

P. S. Mathur

(Sugarcane Research Station, Shahjahanpur, U.P.)

Introduction

Mulches have been used in different countries. Landrau and Samuels (1952) observed that aligning sugarcane trash in the field reduced weeding costs. Average yield for the farm adopting the practice of collecting and spreading the trash into alternate interspaces according to Blundell (1954) was 48·4 tons cane per acre as compared with the average yield for the district of 28·8 tons. Ploughing in trash followed by ploughing in legume, usually sunn hemp, in Natal as reported by King (1953), gave very little response in plants and first ratoons; production in later ratoons progressively increased. In South Africa (1958) the effect of trash blanketing has been so marked that " what was sandy soil has now taken on a different character entirely and has become granulated ". Leake (1954) reported that at Bundaberg no benefit was found to follow 20 years of trash conservation while beneficial results were noted in Barbados and more recently in South Africa. Lugo-Lopez *et al.* (1952) presenting data for various soil characteristics on plots where sugarcane trash had been either burned, buried or aligned, stated that no significant differences were observed between the mean pH and total nitrogen values of soil under the various treatments. The mean organic matter from plots where trash was burned was significantly lower than that of soil from plots where it was buried or aligned.

In India Bose (1954) stated that trash mulch 3″-4″ deep provided immediately after planting of cane gave about 52 to 85 mds. more cane per acre than the artificially mulched plots. He opined that in addition to increased tonnage this system induced better growth of crop and produced healthier canes.

Trash mulch thus holds promise but information about the practice under Indian conditions is very meagre. It was, therefore, thought desirable to test the utility of trash mulch in suppressing the growth of weeds, conserving soil moisture and ultimately giving higher cane tonnage under our conditions. The present paper discusses the results of a number of experiments carried out in Uttar Pradesh.

Material and Methods

The present findings relate to observations taken from experiments at Shahjahanpur, Jamunabad Farm (District Kheri), Khurpia farm and Tarai State Farm, Phoolbagh (District Nainital) and at Panwaria Farm (District Rampur), which were laid out in simple randomised blocks with the treatments and replications as shown in table I.

Counted number of 3-budded setts were planted in each of the experiments and the number, from experiment to experiment, depended upon the length of the rows. Soon after germination of cane in the month of April, trash (dried sugarcane leaves) cover, about 2″ to 4″ thick was provided in between the lines of cane. This cover was made about 6″-8″ thick at Khurpia farm and Tarai State Farm because of the tenacious grass weeds found there. This treatment was compared against normal cultivation wherein regular hoeings and weedings were undertaken. Control plots were given no hoeings except one to ensure proper germination. Another treatment tested at Shahjahanpur for two years, consisted of application of 15 lbs. N per acre as ammonium sulphate with trash application.

At Khurpia farm the experiment was laid out in October planted cane while at all the other places cane was planted in Spring. Observations on germination per cent buds planted, tillers per plant, millable canes at harvest, soil moisture, cane height, juice quality and yield of cane were recorded. Weed population as affected by the different treatments was also recorded. The population of different weeds at different times was studied within one ft. square quadrat thrown five times at random in each experimental plot.

Findings

Germination

Average germination (Table II) was almost similar in all the treatments of an experiment and it differed from experiment to experiment probably because of the different climatic, soil and varietal differences obtaining during those years and at different places.

TABLE I

Treatments of the various experiments

Sl. No.	Place and year	Treatments	Variety of cane	Replications	Plot size
1.	Shahjahanpur (1954-55)	(1) Trash cover (2) Normal cultivation (3) control	Co. 453	4	25′×18′
2.	Shahjahanpur (1955-56)	(1) Trash cover (2) Trash cover + Ammonium sulphate at 15 lbs. N. per acre (3) Normal cultivation (4) Control ..	Co. 453	4	35′×18′
3.	Shahjahanpur (1956-57)	(1) Trash cover (2) Trash cover + Ammonium sulphate at 15 lbs. N. per acre (3) Normal cultivation (4) Control ..	Co. 453	5	30′×18′
4.	Shahjahanpur (1957-58)	(1) Trash cover (2) Normal cultivation (3) control	Co. 453	4	45′×18′
5.	Panwaria Farm Rampur (1957-58)	(1) Trash cover (2) Normal cultivation (3) Control	Co. S. 514	5	26′×15′
6.	Jamunabad Farm Kheri (1956-57)	(1) Trash cover (2) Normal cultivation (3) Control	Co. S. 416	6	50′×24′
7.	Jamunabad Farm Kheri (1957-58)	(1) Trash cover (2) Normal cultivation (3) Control	Co. S. 416	6	44′×18′
8.	Khurpia Farm, Nainital (1957-58)	(1) Trash cover (2) Normal cultivation (3) Control	Co. S. 514	6	50′×24′
9.	Tarai State Farm Nainital (1957-58)	(1) Trash cover (2) Normal cultivation (3) Control	Co. S. 245	6	58′×15′

TABLE II

Average germination percentage

Sl. No.	Treatments	Shahjahanpur				Jamunabad Farm		Khurpia Farm	Panwaria Farm 1957	Tarai State Farm Phoolbagh 1957
		1954	1955	1956	1957	1956	1957			
1.	Trash cover ..	48·9	31·5	41·2	30·7	41·2	33·4	Germination data not recorded	47·7	56·4
2.	Normal cultivation	56·3	31·5	42·1	34·6	42·2	32·4		47·7	53·7
3.	Control ..	54·8	28·2	41·9	30·3	41·8	32·9	..	45·9	57·4
4.	Trash Cover + Ammonium sulphate	..	30·6	41·4	..	..	..	..	..	..

Thus as expected, germination was almost uniform in all the plots, there being no treatment differences prior to germination.

Tillers per plant

Average number of tillers per plant (Table III) was the highest in normal cultivation treatment where proper hoeings and weedings were undertaken. Tillers per plant figures were generally the lowest in control plots, while in the trash cover treatment the average tillers per plant were either comparable to or slightly less than obtaining in normal cultivation treatment. This was the case in all the varieties during different years and at different places.

TABLE III

Average number of tillers per plant

Sl. No.	Treatments	Shahjahanpur				Jamunabad Farm		Khurpia Farm	Panwaria Farm	Tarai Farm
		1954–55	1955–56	1956–57	1957–58	1956–57	1957–58	1956–57	1957–58	1957–58
1.	Trash cover ..	2·7	1·4	2·9	4·3	2·2	5·5	Data not recorded	Data not recorded	3·1
2.	Trash cover + Amm. sulphate ..	..	1·1	3·0	..	..	..			..
3.	Normal Cultivation	2·6	2·0	3·4	4·0	2·6	5·8			3·6
4.	Control ..	2·4	1·5	3·1	2·9	2·6	5·3			3·2

Total millable canes

Data for average number of millable canes per acre were recorded in the experiments as shown in Table IV.

TABLE IV

Average number of millable canes per acre

Sl. No.	Treatments	Shahjahanpur				Jamunabad Farm		Khurpia Farm	Panwaria Farm	Phoolbagh Farm
		1954–55	1955–56	1956–57	1957–58	1956–57	1957–58			1957–58
1.	Trash Cover ..	39,882	31,563	Not recorded	41,248	40,116	43,787	Not recorded	Not recorded	40,275
2.	Trash cover + Amm. Sulphate ..	..	31,114		..	..	..			..
3.	Normal cultivation	43,366	33,477		40,602	40,350	43,768			40,824
4.	Control ..	36,494	29,420		30,384	39,317	41,586			39,594

As in the case of average number of tillers per plant, millable cane number at harvest was also generally highest in the normal cultivation plots, and lowest in control. The trash cover treatment, even without hoeings, gave considerably higher number of millable canes at harvest as compared to the unhoed control plots and at Jamunabad farm, Phoolbagh and Shahjahanpur (1957-58) it even gave figures comparable to those obtained under properly hoed normal cultivation treatment.

Weed occurrence

Observations on weed occurrence were recorded at Shahjahanpur in 1954-55, 1956-57 and 1957-58 and the data are presented in Tables V, VI and VII.

TABLE V

Average population of weeds per sq. foot

Shahjahanpur (1954-55)

Sl. No.	Name of weeds	Control		Trash Cover	
		22–5–54	11–6–54	22–5–54	11–6–54
1.	*Cyperus rotundus*	10·1	7·0	4·35	3·5
2.	*Portulaca oleracea*	0·3	0·3	nil	nil
3.	*Cassia tora*	0·1	..	nil	..
4.	*Sesbania aegyptiaca*	0·05	..	nill	..
5.	*Phyllanthus niruri*	0·05	..	nil	..
6.	*Convolvulus arvensis*	0·05	..	0·3	0·3
7.	*Ipomaea pestigridis*	..	Nil	..	0·1

TABLE VI

Average population of weeds per sq. foot

Shahjahanpur (1956-57)

Sl. No.	Name of weeds	Control		Trash cover		Trash cover+ Ammonium sulphate	
		9-5-56	5-6-56	9-5-56	5-6-56	9-5-56	5-6-56
1.	*Cyperus rotundus*	22·4	26·4	5·3	5·1	4·6	3·7
2.	*Portulaca oleracea*	2·1	3·1	Nil	Nil	Nil	0·04
3.	*Phyllanthus niruri*	Nil	0·45	Nil	Nil	Nil	Nil
4.	*Trianthema monogyna*	0·04	0·3	Nil	Nil	Nil	Nil
5.	*Euphorbia hirta*	Nil	0.3	Nil	Nil	Nil	Nil
6.	*Corchorus acutangulus*	Nil	0·3	Nil	Nil	Nil	Nil
7.	*Cassia tora*	0·4	0·68	0·04	Nil	0·12	0·1
8.	*Commelina benghalensis*	Nil	0·04	Nil	Nil	Nil	0·04
9.	*Euphorbia geniculata*	0·08	0·08	Nil	Nil	Nil	Nil
10.	*Ipomaea pestigridis*	0·04	0·04	Nil	Nil	Nil	Nil

TABLE VII

Average population of weeds per sq. foot

Shahjahanpur (1957-58)

Sl. No.	Name of weeds	Control	Trash Cover	Normal cultivation
		9-8-57	9-8-57	9-8-57
1.	*Cyperus rotundus*	70·8 gms.	3·0	9·4
2.	*Cynodon dactylon*	(Weight of all weeds per sq. ft.)	Nil	A few plants here and there
3.	*Euphorbia hirta*	..	Nil	0·2

Cyperus rotundus, one of the most obnoxious weeds in sugarcane crop during the months of April, May and June was considerably suppressed by trash cover treatment. As seen from the tables given above the population of this weed in trash cover plots ranged between 3 to 5 per sq. foot as against 10 to 26 in the control plots. In Table VII fresh weight of weeds per sq. foot is given under control treatment as by the time this observation was taken in the experiment, growth of weeds was so profuse in the control plots that it was extremely difficult to count the numbers there. Hence all the weeds in the square quadrat were cut at the surface of the ground and fresh weight of all these was recorded. Under the trash cover and normal cultivation treatments, however, number of weeds per sq. foot is given. This year as seen from Table VII even four months after the spreading of trash, average population of *Cyperus rotundus* in the trash plots was only 3 per sq. foot as against 9·4 in the normal cultivation plots. In the control plots the growth of *Cyperus rotundus* and other weeds was profuse as evident from the average fresh weight of weeds recorded here.

Other weeds viz., *Portulaca oleracea, Cassia tora, Sesbania aegyptiaca, Phyllanthus niruri, Trianthema monogyna, Corchorus acutangulus, Commelina benghalensis, Euphorbia hirta, Euphorbia geniculata* and *Cynodon dactylon* did not come up at all in the trash plots although they had fair population in the control plots (Tables V, VI and VII). Some plants of *Ipomaea pestigridis* and *convolvulus arvensis* did come up in the trash plots in 1954-55 (Table V) Plate 1 depicts through 3 photographs condition of the crop and population of weeds under the different treatments. Photographs were taken at Shahjahanpur about 3½ months after spreading trash.

PLATE I

EFFECT OF TRASH MULCH ON SUPPRESSION OF WEEDS

FIG. 1. Normal Cultivation (with hoeings) plot free from weeds

FIG. 2. Trash mulch plot (without hoeings) free from weeds

FIG. 3. Control plot full of weeds

Moisture content of soil

Moisture Content of soil was determined in all the differently treated plots at Shahjahanpur during 1956-57 both prior to trash application and about 17 days after it was applied. The data are given in Table VIII and Plate II.

Moisture content of soil prior to trash application did not vary in the different plots and it ranged on April 18, between 8·3 per cent to 8·9 per cent upto a depth of 0-6″ and between 10·8 per cent to 11·2 per cent at the depth of 6″-12″. Trash was applied on April 21 and the next day the field was irrigated. The observations taken 17 days after the application of trash, in the hot month of May revealed very appreciable differences in the moisture content of soil. Surface six inches soil in the control and normal cultivation plots had a moisture content of 2·8 per cent and 5·3 per cent respectively. At a depth of 6″ to 12″ the corresponding figures were 5·8 per cent and 8·7 per cent. As against this the soil moisture content in trash cover plots at both the depths was as high as 12·1 to 12·6 per cent.

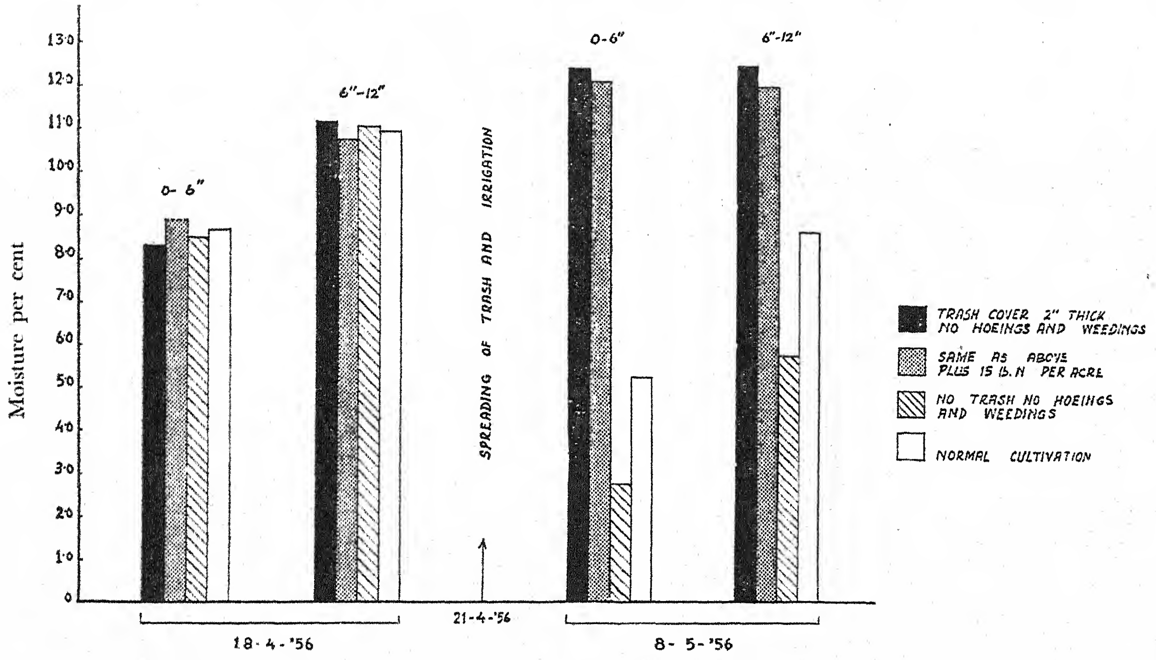
TABLE VIII

Moisture content of soil (per cent dry weight)

Sl. No.	Treatments	Before applying trash 18–4–56		17 days after applying trash 8–5–56	
		0′–6″ depth	6″-12″ depth	0′–6″ depth	6″-12″ depth
1.	Trash cover	8·3	11·2	12·5	12·6
2.	Trash cover + Amm. Sulphate ..	8·9	10·8	12·2	12·1
3.	Normal cultivation	8·7	11·0	5·3	8·7
4.	Control	8·5	11·1	2·8	5·8

PLATE II

EFFECT OF TRASH MULCH ON MOISTURE CONTENT OF SOIL



Cane height

Observations on height of the longest cane in the clump were recorded at Shahjahanpur, during 1954-55 and 1956-57, at Jamunabad farm during 1956-57 and 1957-58 and at Khurpia farm during 1956-57. The data are presented in Tables IX and X.

TABLE IX

Average height of the longest tiller in the clump (Shahjahanpur)

Sl. No.	Treatments	1954					1956			
		23-6-54	14–7–54	27–8–54	21–9–54	22–10–54	25–5–56	6–7–56	6–8–56	12–9–56
1.	Trash Cover ..	2′–6″	4′–3″	7′–6″	9′–1″	9′–8″	1′–3″	4′–1″	6′–7″	9′–3″
2.	Trash Cover + Ammonium Sulphate	..	..	..	..	..	1′–4″	4′–2″	6′–10″	9′–5″
3.	Normal cultivation	2′–3″	4′–0″	7′–2″	8′–9″	9′–6″	1′–0″	3′–7″	6′–4″	8′–9″
4.	Control ..	2′–1″	3′–8″	6′–8″	8′–3″	9′–0″	1′–0″	3′–7″	6′–1″	8′–7″

TABLE X

Average height of the longest tiller in the clump (Jamunabad Farm and Khurpia Farm)

Sl. No.	Treatments	Jamunabad Farm (1956)						Jamunabad Farm (1957)				Khurpia Farm (1956)				
		June	July	Aug.	Sep.	Oct.	Nov.	22–6 1957	22–7 1957	20–8 1957	24–9 1957	27–5 1956	27–6 1956	28–7 1956	30–8 1956	24–10 1956
1.	Trash Cover ..	1′-0″	3′-2″	4′-9″	5′-7″	7′-10″	7′-10″	1′-6″	4′-3″	5′-9″	7′-0″	1′-8″	4′-10″	6′-11″	8′-11″	10′-7″
2.	Normal cultivation	0′-9″	2′-6″	4′-7″	5′-6″	7′-3″	7′-4″	1′-7″	4′-2″	5′-7″	6′-10″	1′-10″	4′-11″	6′-10″	8′-11″	10′-6″
3.	Control ..	0′-10″	2′-9″	4′-6″	5′-5″	7′-4″	7′-6″	1′-8″	4′-4″	5′-8″	6′-11″	1′-9″	4′-11″	6-′11″	8′-10″	10′-6″

Average height of cane was invariably maximum in the trash cover plots and minimum in the control plots (Tables IX and X). Even the normal cultivation plots had generally canes shorter than the trash cover plots. It is interesting to note that at Jamunabad farm in 1957 and at Khurpia Farm in 1956, even when initially in May or June the height of cane was less in the trash plots as compared to both normal cultivation and control treatments, it not only caught up with them but at harvest the canes in trash plots were longer in comparison to those in other treatments.

Quality of cane

Table XI gives Sucrose per cent juice and purity coefficient determinations at Shahjahanpur. It was seen that the quality of cane in the Trash cover plots was comparable to that in the Normal cultivation plots.

TABLE XI

Average sucrose per cent juice and purity coefficient (Shahjahanpur Co. 453)

Sl. No.	Treatments		28–12–54	26–11–57	11–12–57	27–12–57
1.	Trash cover	Sucrose	16·48	13·95	14·79	16·01
		Purity	86·5	82·59	84·46	88·40
2.	Normal Cultivation ..	Sucrose	16·25	13·94	15·24	16·22
		Purity	86·2	82·03	84·70	88·18
3.	Control	Sucrose	16·81	14·03	14·47	16·06
		Purity	87·4	82·42	84·20	89·01

Yield of cane

Cane yield data for the different experiments are presented in Table XII. It is seen that under trash cover treatment even without any hoeings and weedings, both at Shahjahanpur and in out station trials and with different varieties, the yield of cane has invariably been comparable to or even better than that obtained with the normal cultivation treatment entailing considerable expenditure on proper hoeings etc.

The yield of cane obtained from trash cover plots was in all tests significantly superior to that obtained from unhoed control plots, except in two cases i.e. at Jamunabad in 1956-57 and Phoolbagh in 1957-58. In these trials also, although the differences have not been statistically significant, trash cover plots gave highest yield of cane and in comparison to unhoed control plots about 60 to 88 maunds more cane per acre was obtained from them. Although there was no significant difference in yields of cane between the trash cover treatment and normal cultivation treatment in majority of the experiments, the former even gave significantly higher yield of cane than the latter at Shahjahanpur in the years 1956-57 and 1957-58 and also at Jamunabad farm in 1957-58.

TABLE XII

Average yield of cane in maunds per acre

Sl. No.	Treatments	Shahjahanpur				Jamunabad Farm		Khurpia farm	Panwaria farm	Phool bagh	Average
		1954–55	1955–56	1956–57	1957–58	1956–57	1957–58	1956–57	1957–58	1957–58	
1.	Trash Cover ..	984·5	568·1	991·0	1101·5	490·0	817·7	739·8	729·5	797·9	802·2
2.	Trash Cover+Ammonium Sulphate ..	..	613·9	1012·8	..	..	..	..	..	..	..
3.	Normal cultivation	1001·9	665·3	960·3	961·7	433·2	723·8	769·9	653·8	737·9	767·5
4.	Control ..	800·5	445·4	879·6	703·8	402·7	671·2	627·5	577·3	737·1	649·4
	S. E. ..	±36·6	±17·6	±30·9	±32·8	±34·4	±27·5	±26·5	±30·3	±21·0	..

Economic consideration

Table XIII gives the cost of production of cane at the Main Sugarcane Research Station, Shahjahanpur and also gives an estimate of profits obtained from the yield of cane from one acre of land based on the average for yields obtained from all the experiments reported herein. Trash cover treatment thus gave a net profit of Rs. 425·70 as against Rs. 350·13 obtained from normal cultivation treatment.

TABLE XIII

Cost of cultivation of sugarcane crop per acre at Main Sugarcane Research Station, Shahjahanpur (1957-58)

Crop and treatments	Preparation of land (Rs.)	Cost of seed (Rs.)	Manuring (Rs.)	Trash covering expenses (Rs.)	Irrigation charges (Rs.)	Cost of hoeings and weedings (Rs.)	Cost of earthing (Rs.)	Transport charges @ 6 N.P. per maund (Rs.)	Total expenditure (Rs.)	Yield in mds. per acre (Average of all the 9 experiments).	Total income Rs. @ 1·31 per md.	Net profit per acre (Rs.)
Sugarcane with normal cultivation	159·17	138·22	88·32	Nil	113·79 for 5 irrigations	74·67 12 hoeings	33·12	48·00	655·29	767·5	1005·42	350·13
Sugarcane with trash cover ..	159·17	138·22	88·32	30·0	113·79 for 5 irrigations	12·44 (2 hoeings before spreading trash)	33·12	50·12	625·18	802·2	1050·88	425·70

DISCUSSION

Although there was no appreciable difference in germination of cane, tiller number per plant was highest in the normal cultivation plots and lowest in control plots, indicating the beneficial effect of hoeings on tillering in cane. Even without hoeings, trash mulch kept the soil in proper tilth and thus tillering was not adversely affected under trash treatment as was the case in no hoeing control plots. Thus at harvest millable cane number in trash plots was considerably higher as compared to unhoed plots and the figures were comparable to those under normal cultivation plots.

Weeds were suppressed considerably by trash cover and *Cyperus rotundus* which is one of the most obnoxious weeds in sugarcane fields, was kept almost completely suppressed by trash blanket which cut off sun light and also did not allow the young plants that germinated to reach above the dry leaf cover. It was seen that whatever weeds came up in the trash cover plots, were mostly confined to such places

where the cover was thin or where the trash was displaced by wind etc. Weeds like *Convolvulus arvensis* and *Ipomaea pestigridis* when they came up in the gaps or where the trash cover was thin thrived very well even in the trash plots because of their twining habit. Thus if the trash cover is fairly uniform and about four inches thick the possibility of weeds coming up in the field is almost negligible. The thickness of the trash covering has to be increased if the area under cane is unusually thickly infested with weeds specially grasses as is the case in *tarai* areas of Uttar Pradesh. In such places the trash cover should be about 6″-8″ thick. In Phoolbagh and Khurpia Farm where grasses are very difficult to control the trash blanket was kept about 6″-8″ thick and considerable control of even the grass weeds common in that area was obtained by this treatment, which ultimately resulted in higher yields from trash cover plots; soil moisture conservation is not so much a problem in Tarai. Trash collected from a two acre field is sufficient to give about 4″ thick cover over one acre field.

Apart from effective control of weeds another important advantage of trash mulching is conservation of soil moisture. As seen from the data presented in Table VIII and Plate II in the trash cover plots, soil moisture, even in the surface six inches of soil was as high as at a depth of 6 to 12 inches. In the hot summer months of April, May and June when the problem of moisture conservation is very acute, trash cover conserved moisture appreciably well even in the surface layers of the soil. In the earlier stages of growth the young cane plant mostly depends for its nutrient and water requirements on the surface feeder roots which do not go very deep. Thus the young cane plants in the trash cover plots, because of better soil moisture status even in the surface layers of soil and effective elimination of competition from weeds, got an impetus even during their early growth phase. Canes in the trash cover plots were thus longer in height even during the early period in their growth (Tables IX and X). Better soil moisture status and suppression of weeds early in the life cycle of cane crop in the trash plots, even without hoeings, resulted in cane yields from these plots as high as those obtained from normal cultivation plots (Table XII). In none of the experiments reported here, did normal cultivation plots give significantly better yield than the trash cover plots. On the other hand at Shahjahanpur during 1956-57 and 1957-58 and at Jamunabad in 1957-58, trash cover treatment gave yield of cane significantly superior to even normal cultivation plots wherein proper hoeings were undertaken.

Considering the average for yields of cane from all the experiments, trash cover plots yielded a net profit of Rs. 425·70 per acre as against Rs. 350·13 only obtained from normally recommended practice (Table XIII). This was due firstly to reduction of expenditure on hoeings and weedings and secondly because of higher yield obtained from the trash cover plots.

Trash mulching can be particularly beneficial where irrigation facilities may be limited or where the land is thickly infested with weeds. In such places soil moisture conservation and control of weeds is of vital importance during the hot summer months when the cane plant is still young.

It is sometimes doubted that trash cover might harbour insect pests which may damage the crop but in all the nine trials reported herein and conducted in different years at various places no serious attack of any pest was observed except at Khurpia farm. Here in 1956-57 army worm (*Cirphis* sp.) appeared in an epidemic form and the larvae found a suitable place in the trash cover. The pest was, however, not localised in the Trash plots alone. The attack was controlled by the entomologist by dusting five per cent BHC dust at the rate of 20-30 lbs. per acre. In case, there is white ant infestation application of chlordane five per cent dust or BHC 5 per cent dust at the rate of 15 lbs. and 20 lbs. respectively per acre can be adopted with advantage (Siddiqi and Agarwal, 1956).

Care should be taken not to use trash from a red rot affected field as that may help in the spread of disease.

Summary

To test the utility of trash mulch in sugarcane cultivation, experiments were carried out at Shahjahanpur and various other places in Uttar Pradesh. The treatments consisted of trash covering after germination with no hoeings and weedings, normal cultivation treatment with proper hoeings and weedings and no hoeing control. The results are summarised below:—

1. Trash cover, 2″-4″ thick, provided after reasonable germination of cane did not very adversely affect tillering of cane although maximum number of tillers per plant was recorded in normal cultivation plots wherein proper hoeings and weedings were undertaken. Lowest number of tillers per plant were recorded in no hoeing control plots.

2. At harvest millable canes per acre in the trash cover plots were comparable in number to those obtained from the normal cultivation plots, the respective numbers being 31,600 to 43,800 in the former and 33,500 to 43,800 in the latter case. Lowest number of millable canes was always obtained from the control plots.

3. Trash cover suppressed the growth of weeds considerably and population of *Cyperus rotundus* was about 70 to 80 per cent less in trash cover as compared to the control plots. *Portulaca oleracea*, *Cassia tora*, *Sesbania aegytiaca*, *Phyllanthus niruri*, *Trianthema monogyna*, *Corchorus acutangulus*, *Commelina benghalensis*, *Euphorbia hirta* and *Euphorbia geniculata* did not come up at all in the trash cover plots although in the control plots their occurrence was appreciable. *Ipomaea pestigridis* and *Convolvulus arvensis* were also suppressed by trash cover but if they came up in gaps or where the cover was not thick enough they thrived well in the trash cover plots because of their twining habit.

4. Soil moisture was very appreciably conserved in trash cover plots during the hot summer months of April, May and June and both in the top 6″ and 6″-12″ layers of soil it remained higher in the trash cover plots as compared to even the normal cultivation plots.

5. Maximum height of cane was observed in the trash cover plots. Control plots had the shortest canes. Although the normal cultivation plots had canes taller than those in the control plots, the former were shorter in height than the canes in the trash plots.

6. Yield of cane from the trash cover and normal cultivation plots was always comparable; mostly there being no significant differences between them. But in three experiments out of nine trash cover gave yield of cane even significantly superior to that got from normal cultivation plots.

7. On the basis of cost of cultivaton of sugarcane at the Sugarcane Research Station, Shahjahanpur (1957-58) trash cover plots, gave on an average a profit of Rs. 425·70 compared with Rs. 350·13 obtained from normal cultivation plots.

8. The beneficial effects of trash covering enumerated above are likely to be of particular advantage in areas where facilities for irrigation do not exist and also at places where weeds are a problem to control.

Acknowledgements

This work was carried out under a sugarcane research scheme financed partly by the Indian Central Sugarcane Committee. The author is grateful to Dr. R. K. Tandon and Dr. J. G. Shrikhande for kind interest and encouragement. Help received from Messrs. S. S. Shukla, B. S. Mathur, K. S. Bisht, R. P. Singh and K. P. Singh in taking part of the observations in the outstation trials, is acknowledged.

References

Anonymous (1958). Soil fertility increased by Trash Blanketing and Fertilizers. *The South* Afri. Sug. Jour., **42** (2): 129-132.

*Blundell, E. (1954). Surface mulching of crop Residues in Ratoons. *Cane Growers Qrar. Bull.*, **17**(3): 96-99 (*I.S.J.*, **LVI** (669): 245).

Bose, R. D. (1954). Artificial Mulching as an Aid to Increase Sugarcane Production—*Proc. Sec. Bie. Conf. Sug. Res. Dev. Work. Ind. Union.*: 396-400.

*King, N. J. (1953). Trash Blanketing in Natal—*S. Afri. Sug. Jour.*, **37** (12): 809-11 (*I.S.J.*, **LVI** (669): 246).

Landrau, Pablo Jr. and Samuels, George (1952). The Handling of Sugarcane Trash I. Yield and Economic Considerations. *The Jour. Agri. Uni. Puerto Rico.*, **XXXVI** (3): 240-25.

Leake, H. M. (1954). The disposal of trash, *I.S.J.*, **LVI** (662): 34.

Lugo-Lopez, M. A., Landrau, P. Jr. and Samuels, G. (1952). The Handling of sugarcane Trash—II. Effects of various practices on Soil properties. *The Jour. Agri. Uni. Puerto. Rico.*, **XXXVI** (3): 246-254.

Siddiqi, Z. A. and Agrawal, R. A. (1958). Effect of soil treatment with chlordane and BHC on the incidence of termite and yield of sugarcane. *Proc. Int. Soc. Sug. Tech. 9th Cong. India*, **1**: 902-7.

*Original not seen by author.

where the cover was thin or where the trash was displaced by wind etc. Weeds like *Convolvulus arvensis* and *Ipomaea pestigridis* when they came up in the gaps or where the trash cover was thin thrived very well even in the trash plots because of their twining habit. Thus if the trash cover is fairly uniform and about four inches thick the possibility of weeds coming up in the field is almost negligible. The thickness of the trash covering has to be increased if the area under cane is unusually thickly infested with weeds specially grasses as is the case in *tarai* areas of Uttar Pradesh. In such places the trash cover should be about 6″-8″ thick. In Phoolbagh and Khurpia Farm where grasses are very difficult to control the trash blanket was kept about 6″-8″ thick and considerable control of even the grass weeds common in that area was obtained by this treatment, which ultimately resulted in higher yields from trash cover plots; soil moisture conservation is not so much a problem in Tarai. Trash collected from a two acre field is sufficient to give about 4″ thick cover over one acre field.

Apart from effective control of weeds another important advantage of trash mulching is conservation of soil moisture. As seen from the data presented in Table VIII and Plate II in the trash cover plots, soil moisture, even in the surface six inches of soil was as high as at a depth of 6 to 12 inches. In the hot summer months of April, May and June when the problem of moisture conservation is very acute, trash cover conserved moisture appreciably well even in the surface layers of the soil. In the earlier stages of growth the young cane plant mostly depends for its nutrient and water requirements on the surface feeder roots which do not go very deep. Thus the young cane plants in the trash cover plots, because of better soil moisture status even in the surface layers of soil and effective elimination of competition from weeds, got an impetus even during their early growth phase. Canes in the trash cover plots were thus longer in height even during the early period in their growth (Tables IX and X). Better soil moisture status and suppression of weeds early in the life cycle of cane crop in the trash plots, even without hoeings, resulted in cane yields from these plots as high as those obtained from normal cultivation plots (Table XII). In none of the experiments reported here, did normal cultivation plots give significantly better yield than the trash cover plots. On the other hand at Shahjahanpur during 1956-57 and 1957-58 and at Jamunabad in 1957-58, trash cover treatment gave yield of cane significantly superior to even normal cultivation plots wherein proper hoeings were undertaken.

Considering the average for yields of cane from all the experiments, trash cover plots yielded a net profit of Rs. 425·70 per acre as against Rs. 350·13 only obtained from normally recommended practice (Table XIII). This was due firstly to reduction of expenditure on hoeings and weedings and secondly because of higher yield obtained from the trash cover plots.

Trash mulching can be particularly beneficial where irrigation facilities may be limited or where the land is thickly infested with weeds. In such places soil moisture conservation and control of weeds is of vital importance during the hot summer months when the cane plant is still young.

It is sometimes doubted that trash cover might harbour insect pests which may damage the crop but in all the nine trials reported herein and conducted in different years at various places no serious attack of any pest was observed except at Khurpia farm. Here in 1956-57 army worm (*Cirphis* sp.) appeared in an epidemic form and the larvae found a suitable place in the trash cover. The pest was, however, not localised in the Trash plots alone. The attack was controlled by the entomologist by dusting five per cent BHC dust at the rate of 20-30 lbs. per acre. In case, there is white ant infestation application of chlordane five per cent dust or BHC 5 per cent dust at the rate of 15 lbs. and 20 lbs. respectively per acre can be adopted with advantage (Siddiqi and Agarwal, 1956).

Care should be taken not to use trash from a red rot affected field as that may help in the spread of disease.

Summary

To test the utility of trash mulch in sugarcane cultivation, experiments were carried out at Shahjahanpur and various other places in Uttar Pradesh. The treatments consisted of trash covering after germination with no hoeings and weedings, normal cultivation treatment with proper hoeings and weedings and no hoeing control. The results are summarised below:—

1. Trash cover, 2″-4″ thick, provided after reasonable germination of cane did not very adversely affect tillering of cane although maximum number of tillers per plant was recorded in normal cultivation plots wherein proper hoeings and weedings were undertaken. Lowest number of tillers per plant were recorded in no hoeing control plots.

2. At harvest millable canes per acre in the trash cover plots were comparable in number to those obtained from the normal cultivation plots, the respective numbers being 31,600 to 43,800 in the former and 33,500 to 43,800 in the latter case. Lowest number of millable canes was always obtained from the control plots.

3. Trash cover suppressed the growth of weeds considerably and population of *Cyperus rotundus* was about 70 to 80 per cent less in trash cover as compared to the control plots. *Portulaca oleracea*, *Cassia tora*, *Sesbania aegytiaca*, *Phyllanthus niruri*, *Trianthema monogyna*, *Corchorus acutangulus*, *Commelina benghalensis*, *Euphorbia hirta* and *Euphorbia geniculata* did not come up at all in the trash cover plots although in the control plots their occurrence was appreciable. *Ipomaea pestigridis* and *Convolvulus arvensis* were also suppressed by trash cover but if they came up in gaps or where the cover was not thick enough they thrived well in the trash cover plots because of their twining habit.

4. Soil moisture was very appreciably conserved in trash cover plots during the hot summer months of April, May and June and both in the top 6″ and 6″-12″ layers of soil it remained higher in the trash cover plots as compared to even the normal cultivation plots.

5. Maximum height of cane was observed in the trash cover plots. Control plots had the shortest canes. Although the normal cultivation plots had canes taller than those in the control plots, the former were shorter in height than the canes in the trash plots.

6. Yield of cane from the trash cover and normal cultivation plots was always comparable; mostly there being no significant differences between them. But in three experiments out of nine trash cover gave yield of cane even significantly superior to that got from normal cultivation plots.

7. On the basis of cost of cultivaton of sugarcane at the Sugarcane Research Station, Shahjahanpur (1957-58) trash cover plots, gave on an average a profit of Rs. 425·70 compared with Rs. 350·13 obtained from normal cultivation plots.

8. The beneficial effects of trash covering enumerated above are likely to be of particular advantage in areas where facilities for irrigation do not exist and also at places where weeds are a problem to control.

Acknowledgements

This work was carried out under a sugarcane research scheme financed partly by the Indian Central Sugarcane Committee. The author is grateful to Dr. R. K. Tandon and Dr. J. G. Shrikhande for kind interest and encouragement. Help received from Messrs. S. S. Shukla, B. S. Mathur, K. S. Bisht, R. P. Singh and K. P. Singh in taking part of the observations in the outstation trials, is acknowledged.

References

Anonymous (1958). Soil fertility increased by Trash Blanketing and Fertilizers. *The South* Afri. Sug. Jour., **42** (2): 129-132.
*Blundell, E. (1954). Surface mulching of crop Residues in Ratoons. *Cane Growers Qrar. Bull.*, **17**(3): 96-99 (*I.S.J.*, **LVI** (669): 245).
Bose, R. D. (1954). Artificial Mulching as an Aid to Increase Sugarcane Production—*Proc. Sec. Bie. Conf. Sug. Res. Dev. Work. Ind. Union.*: 396-400.
*King, N. J. (1953). Trash Blanketing in Natal—*S. Afri. Sug. Jour.*, **37** (12): 809-11 (*I.S.J.*, **LVI** (669): 246).
Landrau, Pablo Jr. and Samuels, George (1952). The Handling of Sugarcane Trash I. Yield and Economic Considerations. *The Jour. Agri. Uni. Puerto Rico.*, **XXXVI** (3): 240-25.
Leake, H. M. (1954). The disposal of trash, *I.S.J.*, **LVI** (662): 34.
Lugo-Lopez, M. A., Landrau, P. Jr. and Samuels, G. (1952). The Handling of sugarcane Trash—II. Effects of various practices on Soil properties. *The Jour. Agri. Uni. Puerto. Rico.*, **XXXVI** (3): 246-254.
Siddiqi, Z. A. and Agrawal, R. A. (1958). Effect of soil treatment with chlordane and BHC on the incidence of termite and yield of sugarcane. *Proc. Int. Soc. Sug. Tech. 9th Cong. India*, **1**: 902-7.

*Original not seen by author.

RELATIONSHIP OF CHEMICAL COMPOSITION OF CANE VARIETIES AND SUGAR RECOVERY

By

P. C. Raheja

(Indian Agricultural Research Institute, New Delhi)

Introduction

NATURALLY the cane sugar factory efficiency is closely linked up with the quality of the cane supplied to the factory. The quality of cane in turn depends on variety, soil type and climatic conditions that place a limit on its sugar accumulation. Not until the production of new varieties by raising seedlings from seed were taken up in the country, the introduction of new varieties was determined by the peregrination of varieties from one country to another.

In India, POJ varieties from Java were introduced as early as 1904 with the first organisation of the Departments of Agriculture at the Centre and in the States. In these introductions the planters in Bihar and U.P., who set up five factories then played no small part. These factories could not find much satisfaction from the new introductions and were always on the look out for new canes to replace the indigenous ones which had very refractory juices. Such juices were not amenable to the clarification processes then in vogue in the sugar factories.

It was not until the Sugarcane Breeding Station at Coimbatore under Dr. C. A. Barber in 1912 was set up that problems of sugarcane industry began to be tackled systematically. The Breeding Station, Java produced varieties that suited the climate of the tropics and it is, therefore, that varieties produced there did not suit extremes of climate in northern India. This fact actually led to the early realization that breeding work at Coimbatore must conform to the conditions under which sugarcane is actually grown in large tracts of India. This laid the foundations of future work on this recognition. Crosses were attempted by Drs. C. A. Barber and T. S. Vankatraman between *S. officinarum*×*S. sponteneum* and *S. officinarum*×*S. barberi*. The former proved extremely successful and first batch of seedlings went out for trial in 1918. These seedlings possessed vigour, had disease resistance and an inherent ability to withstand extremes of climate. They, therefore, were quickly adopted by the farmers all over Northern India.

Characteristic Features of 'Gur' and Sugar Varieties

Indigenously '*gur*' was the main item of diet of the majority of the people in India prior to the introduction of fiscal protection to sugar industry. Even today over 52·6 per cent of the cane is utilized towards the manufacture of '*gur*' as against about 26·3 per cent for the manufacture of sugar in the vacuum pan factories. Therefore, there has always been a quest for good '*gur*' canes. The chief essential of a good '*gur*' cane is that its juice on solidification sets well and it maintains that hardness throughout the monsoon season. Besides, it should have fine yellow colour, good taste, crystalline texture and long keeping quality. Constituents pectins, gums and waxes do not stand in the way of obtaining high quality '*gur*' but are a source of considerable trouble in the clarification processes in the sugar industry. High glucose canes have always been rejected by the '*gur*' industry as unsuited for the production of fine quality product. It is axiomatic to say that high glucose content canes usually have low C.C.S. value.

The introduction of new seedling canes from Coimbatore in 1918 was, therefore, not kindly taken by the farmers. Their spread was more marked on lands which supplied cane to the few factories (about 12 in number) then in existence in Northern India. In India *Pundia* and other noble canes continued to dominate the cane cultivation. Soon, however, marked difference in cane yields between the indigenous and the seedling canes won over the pejudices of the farmers and they began to adjust their cultural practices to suit the conditions necessary for successful '*gur*' production. For instance in the N.W.F.P. Poundah variety held the field prior to 1929 when red rot (*Collectotricum fallcatum* went) disease heavily infected the crop in the main sugarcane tract and no seed was left uninfected to be planted next year. The seedling canes were readily taken up to replace them. But the quality of '*gur*' given was very poor compared to that of 'poundah' variety. Ratooning and the practice of manuring and irrigation of the crop were modified to overcome the poor setting quality of the '*gur*'. Though the extraction was low by about 5 per cent the fibre content being high, extra fuel was not needed and the saving in fuel made up for the loss in extraction of juice from cane.

On the other hand, the sugar industry was fortunate to have seedling canes which possessed very desirable features from the factory point of view. Firstly, the availability of raw material from a smaller area was ensured; secondly, the juices of these canes were less refractory and more amenable to clarification treatment; thirdly, the canes had high fibre content and bagasse had high fuel value so that extra fuel was not needed to work and fourthly, the texture of the crystal formed was more bold. This is evident from the fact that not only five factories which were working at the close of 1920 continued to work but new ones were established as time elapsed. Some 31 sugar factories were set up prior to the introduction of the fiscal protection in 1932 to the sugar industry. Twenty-six of these were situated in the cane belt of U.P. and Bihar. The production of these factories could enter into competition with those of Java factories primarily because of the availability of good quality raw material. The quality of canes was not as good as the cane crushed in Java centrals. The difference was chiefly due to climatic conditions prevailing in the tropics, conducive to high sugar accumulation compared to North Indian sub-tropical climate. Even the success in later development of the factory sugar industry, after the grant of the fiscal protection, is in no small measure due to this fundamental improvement in varietal position.

From the factory point of view a variety to be successful must have chemical composition which would not create trouble in the milling department; shall not be a source of shortage in the fuel department; and the handling of its juices and resultant massecuites shall not cause inconvenience at the various stations in clarification, crystallization and centrifuging processes entailing as low as possible in purged out molasses, in carmalization and so on.

Milling Problems

In connection with varieties the milling problems continuously arise, particularly when more varieties than one are milled at one and the same time. The chief difference lies in the fibre content in cane. In tests carried out at the Takhati-Bhai Sugar Mill, N.W.F.P. with Co. 290 and Co. 419 it was observed that the average indicated horse-power per ton of fibre required to grind Co. 290 and Co. 419 was 60·5 and 48·7 respectively. The differences in the bagasse per cent as determined at test time were 25·60 and 18·10 per cent of the whole cane. The extraction percentages also varied according to the differences in bagasse content which in the two cases were 79·40 and 89·75 per cent. The result of this high extraction in Co. 419 was that, in spite of low polarisation of the Co. 419 raw juice, the final recovery was higher in Co. 419 than Co. 290.

Noel Deerr (1921) determined the extraction of sugar from pith, rind and the whole cane and observed that pith yields its sugar in juice much more quickly than the rind. The greater the proportion of pith to rind bundles, the higher was the extraction of sugar from cane. Evidently softer varieties would be more amenable to milling than high fibred canes.

In 1931, Second Conference of Queensland Society Sugarcane Technologists, Bundaberg, considered a committee report on milling problems and suggested that pushers may be installed when it is intended to mill soft canes and where juice grooves are absent.

Rind hardness is closely related to the fibre content in cane is a well known factor (Ueno, 1928). It is a function of number of vascular bundles per unit volume in rind, lignification of the cell walls of the vascular sheaths and lignification of the inter-vascular parenchyma. These characters or in combination contribute to rind hardness (Khanna and Panje, 1939) . Anyone of these factors is responsible for causing disintegration of the bagasse into small particles or slippage at the rollers. In Bihar B.O. 11, when introduced into factory areas showed high slippage, due to lack of cohesion within the bagasse blanket and brittleness in the bagasse structure, due to smaller number of vascular bundles. Also varieties which have a greater number of elongated hexagonal sub-epidermal cells may cause slippage. Besides, shape and size of parenchyma cells influence the slippage. Varieties with broad, squarish cells having lesser number of cell walls per unit volume offer lesser resistance than varieties possessing squarish and very compact cells, and, therefore, the former have lesser slippage than the latter (Ramanujam, 1956).

Srivastava, Van Der Meyden and Khan (1943) have gone over the question of milling control in relation to the composition of cane varieties and have stated, " The system of milling control practiced in India is more elaborate and involves the computation of milling efficiency, reduced milling efficiency and the quantity of juice lost in the final bagasse per cent fibre in it. But the method of calculating the reduced milling efficiency is satisfactory only so long as the amount of fibre per cent cane does not differ materially from $12\frac{1}{2}\%$" When such is not the case authors have suggested the calculation of two coefficients, namely,

(a) Undiluted juice in cane per cent fibre,

(b) Undiluted juice expressed by each mill per cent fibre.

For working out these coefficients formulae have been suggested.

Arceaneux (1945) based on 13 years experimental test, has stressed the importance of working out 'Varietal Correction factor' so as to avoid important sources of systematic errors which arise due to varietal differences in milling qualities and in the calculation of theoretical yields of sugar from cane.

Thus it is evident that varieties create milling problems and it is sound policy in the interest of the farmers and the factories to have as few varieties as possible within their working zones, which have less tendency to slippage at the rollers and do not show disintegration of bagasse during milling.

Problems of Fuel Department

Noel Deerr (1921) stated, "as far as economy in fuel goes, the question of the boiler is not a dominant one and economy is chiefly a matter of furnace design and careful control of the combustion of the megass". He also discussed the fuel value of bagasse as influenced by variety. In actual practice bagasse of some varieties in 'steam' are much worse than others. Heriot (1920) had recorded that a very porous bagasse burnt under natural draught allowed too much air to enter between the gratebars per unit weight of bagasse burnt and as such excess air increases the heat losses in the chimney.

Prinsen Geerligs (1924) observed, "The question of the fuel value of a megasse is reduced to one of the mechanical structure of the fibre; a megass of low apparent specific gravity will thus occupy a large volume per unit of weight, the volume of megass which can be heaped on the grate of a furnace is limited and with the megass of low density it may happen that the supply of fuel to the furnace is not sufficient to maintain steam for the factory's need, when a different type of megass is being fed, owing to its greater apparent specific gravity and greater weight is contained on the grate without any change in volume, and steam is kept up without difficulty." Daymond (1942) found that the bagasse of Co. 290 was inferior in its steam raising quality to that of Co. 281.

He further goes on to conclude, "This matter is one of great importance in furnace design, as a ratio of grate area to heating surface which gives excellent results with the megass from one variety of cane may be quite insufficient when the megass from another variety is being stoked, although the total heat units available per ton of cane may be identical in both instances."

From the above we may infer that for proper assay of a variety from fuel point of view we should be acquainted with the following facts:—

(a) Fibre content of cane with the purpose of determining the superiority of a variety from fuel value point of view.

(b) Mechanical structure of the fibre and its apparent specific gravity as factors for adjusting grate area to meet the steam requirement for the factory's need.

At the Sugarcane Research Stations no particular attention is paid to the determination of the quality of the fibre, either its mechanical structure or its specific gravity. The per cent fibre content in cane is determined as a routine matter to work out the commercial cane sugar value of the varieties. The comparative results of some of the varieties are given as under:—

Table I

Mean Fibre per cent in varieties

Mid-season series	Co. 290	Co. 312	Co. 419	Co. 331	Co. 438	Co. 451	Co. 584
	11·5	10·8	10·0	12·0	16·0	15·0	14·0
Medium early	Co. 290	Co. 313	Co. 396	Co. 446	Co.K.31	Co. 527	
	11·5	11·5	11·2	9·8	11·1	11·5	

In the case of mid-season series the results are the mean values of four seasons while the mean value for the medium-early series is comprised of two years' data only. It may be stated in passing that the sugar factory at Takhati Bhai with supply of variety Co. 290 for milling purposes experienced considerable shortage of fuel during the first three seasons. In the working season 1944-45 the grate area of the furnace was reduced and furnaces were designed to cover up the shortage experienced in the preceding years. It is, therefore, important to keep in view the fibre content of cane as well as the quality of fibre in cane prior to its being recommended in any factory area.

Ramanujam (1956) noticed steaming difficulties in the Gauribazar Factory and ascribed this to inferior steam raising value of bagasse from Co. 419 in spite of the fact that the moisture per cent bagasse in this variety was not greater than other varieties. But one peculiar fact noted was that when milled the fibre, structure breakdown was greater than in other canes. Co. 419 had fine particles as ' dust ' in the bagasse, to the extent of 18 per cent as against eight per cent in Cos. 416. Studies on the anatomy of Cos. 419, 453 513, B.O.s 10, 11, 24 and *Bhuvli* showed that the structure of bagasse differs with different varieties. The steaming quality is dependent upon the compactness of the bagasse structure as it is related to the quantity of fibre ' dust ' present in bagasse, the steaming quality being superior in bagasse containing less ' dust '.

But for the '*gur*' industry it would be preferable to have varieties with low fibre content. This will mean high extraction from the cane. The bagasse having high cuticle+vessel cortex ratio will dry more quickly and provide fuel of high energy value. The outlet for flow of air and grate area can be varied in the '*gur*' furnace at a small cost. Parthasarathy and Lakshmi Kantham (1951) noted, "Soft juicy canes like Purple Mauritius and Co. 419 are ideal to crush in bullock-drawn crushers for making jaggery. Co. 527 and Co. 449 are more fibrous and are better milled in power driven crushes."

Handling of Juices and Massecuites

Introduction of new varieties very often introduces new troubles and aggravates old ones. This more often happens in juice clarification and treatment of massecuites than in other processes in the factory. The cause of trouble may be organic acids, ash, pectins and gums, colouring substances and colloidal substances.

Saint (1931) reported that the ash, phosphate and potash content of Ba. 11569, B.H. 10912 and B. 3081 are practically the same, but are significantly different from those of B. 417, B. 374 and White Transparent. Walton and Fort (1932) have recorded similar observations on cane juice of varieties in vogue in Louisiana. They further reported that not only their composition in respect of sucrose, invert sugar, acidity, total ash, P_2O_5, Fe_2O_3, Sio_2, total organic non-sugars and gums vary but ' these variations affect in a measurable degree the variations of the juices '. In a subsequent publication Fort and Walton (1932) reported that a variety with high sucrose content may also have a large proportion of mineral matter and organic non-sugars. They have summarised the data from six varieties. It is of interest to us that they examined Co. 281 and Co. 290. In the case of former variety they observed that it was characterised by low percentage of reducing sugars, high true sugar and high ash. Its juice was of lighter colour than that of P.O.J. 213 and only 35 per cent darker than that of P.O.J. 36-M. The variety Co. 290 resembled Co. 281 in most of its juice characters. It had a high ash content, unusually low nitrogen content with relatively high percentage of reducing sugars and lime salts. In strong contrast to Co. 281 the variety P.O.J. 36-M had a rather high content of reducing sugars which was compensated by quicker elimination of non-sugars, for, the variety had low ash and low organic non-sugars. In consequence the syrup of variety Co. 281 after clarification and evaporation showed the highest ratio of sucrose to non-sugars. The high nitrogen content of P.O.J. 213 and P.O.J. 234 gave, under ordinary circumstances, a sugar of darker colour and poor keeping quality.

At most of the Sugarcane Research Stations observations recorded on juice quality are limited to total solids, polarization and estimation of reducing sugars. Since other chemical constituents are important for sugar manufacture these must be determined to ensure that problem in handling juices do not arise in the factory.

Testing of varieties against frosts is a special problem peculiar to North Western India. The frosts not unusually affect the quality of the juice. Deterioration sets in resulting in inversion of sucrose into reducing sugars. Presence of acids in disproportionate quantity in conjunction with the complex enzymic system in operation in plant cell, accelerates the rate of inversion. Therefore, titratable acidity values should be determined in addition to the routine juice analysis.

In the N.W.F.P. titratable acidity was determined and the data obtained were as follows:—

Table II

Titratable acidity *Na OH* *N/10*

	Co. 290	Co. 312	Co. 419	Co. 451
Plant	8·96	10·73	10·26	10·37
Ratoon	14·29	12·75	13·64	12·93

Variety Co. 290 had the lowest value for acidity in plant crop amongst the different varieties. The differences amongst other varieties were not appreciable. In the ratoon crop the juices of varieties Co. 312 and Co. 451 had lower acidity. The apparent differences between the plant and ratoon crop are not the actuals. The mean acidity of the plant crop was recorded on 10th March while in the case of ratoon crop they were limited to mid-December only by which time the crop, whether plant or ratoon, possesses high acidity.

Lander and Narain (1936) have shown that high mineral content of juice from the Punjab canes is the result of high calcium content of the Punjab soils with a slightly higher pH value. In the N.W.F.P. factory recoveries have not suffered on this account except when cane from alkaline soils was crushed. Such a cane was useless for '*gur*' manufacture as its '*gur*' would not set.

For treating cane juices which are rich in glucose Harloff and Schmidt (1913) have suggested that sulphitation process is more appropriate than carbonation for it is accompanied by the formation of soluble carbonates which have the greatest capacity of decomposing glucose. Originally a small amount of glucose is always present in a specially active form. In alkaline solutions, i.e. pH 8 and high at the temperatures approaching 100° C. the rate of formation of active glucose is increased at the rate of $(10)^9$. Besides calcium salts of glucose have the properties of colloids which present difficulties in clarification.

Contrarily sulphurous acid saturation is only suitable where cane varieties milled for sugar are not too much coloured. The chief difference lies in the easy filterability by carbonation process not only of dilute and concentrated juices but of much more viscous syrups, as gummy and petic substances and suspended impurities are readily precipitated. Kloppenburg (1943) has described carbo-sulphitation process to derive advantage of both the processes. This is possible with a slight modification in the plant.

As 'process colloid' the glucose decomposition products colour the crystal and hinder the process of crystal formation. Further, the glucose decomposition products include many dark coloured compounds and several others which have highly viscous solution as glyceric acid, determination is, therefore, considered very essential.

The high colloidal content in juice of certain cane varieties may cause delays amounting in some cases to loss of 5 to 8 per cent of time of clarification. The colloids causing this delay may be of 'inherent colloids' in the juice of certain varieties or may be 'extraneous colloids' entering the mill together with the cane stalk. From the point of view of this discussion inherent colloids are of importance. Pectin compounds, pentosans, waxes, fats and fatty acids, poly-phenols, proteins and starch in cane juice may at some stage under certain temperatures become source of trouble. If pectins be not eliminated they slow down the velocity of crystallization and affect the shape and purity of sugar crystals. Proteins if not coagulated by heat cause difficulty of filteration. Diseased and damaged cane possess larger quantities of pentosans than normal canes. All these three together require larger quantities of lime for their elimination. Wax on heating melts and forms a collidal complex. It is often the major cause of turbidity of clarified juice. It stays in the juice and is deposited on the surface of the sugar crystal and thus may prevent the crystallization of a onsiderable part of the sugar present in the juice. Thus varieties which give out juices with high wax content are less desirable from the factory point of view. It is an admitted fact that indigenous canes were more waxy in nature than the new varieties and as such their juices were more refractory in the mill (Korteschak, 1939).

Soragato (1936) and Browne and Zerban (1941) regarded soluble nitrogen compounds, comprised of amino acids as very troublesome in the process of clarification of juices. They recommended the evolving of varieties of low nitrogen content. Small amounts of gums and alluminoids in juice are good characters of superior quality factory canes (Alvarez, 1938).

According to Korteschak (1939), " Starch is much less the trouble, it is glucose decomposition products which become source of trouble. " It is a typical lyophilic colloid. Its properties resemble those of pectins. But its viscosity is lower than pectin and it does not combine with acids in the juice. Most varieties do not contain much of starch.

Davis (1939) observed that organic silica in juice was inversely proportional to claribility of the cane juice. According to Ness (1941) lower sugar recoveries are obtained when juice contains high silica, alumina and magnesia. Mohan Rao *et al.* (1951) noted that with heavy nitrogenous fertilizer application the amounts of organic non-sugars and non-protein nitrogen increased and level of phosphate decreased and in consequence they adversely affected the quality of '*gur*'. Khanna and Chacravarti (1951) recorded that varieties Co. 313 and Co. 513 had very low levels of total colloids, gums, pectins, and ash but high level of phosphates, as compared to Co. 453. In consequence the former variety gave high nett rendement in the open pan sugar manufacture. The *khandsari* sugar has light colour and very low mineral matter. Ash in colloidal fraction was positively correlated to colour, acidity and ash in '*gur*'. Non-protein nitrogen, SiO_2, $Fe_2O_3+Al_2O_3$ and CaO in juice were positively correlated to turbidity of '*gur*' solutions and in consequence poor quality of

'*gur*'. Khanna and Chacravarti (1955) further observed that different varieties exhibit large variations in quality of '*gur*' even though manufactured under identical conditions. The claribility does not ordinarily depend upon sucrose content in juice. Even though the sucrose in juice may be of the same order, the quality of '*gur*' from different varieties indicates sharp contrasts. The contrasting differences are the consequence of variations in inherent colloids (Kortscher, 1939) such as pectins, pentosans, proteins, waxes and starches existing in lyophillic colloidal state and fats. Parthasarathy (1956) observed that '*gur*' from Co. 527 is superior to that from Co. 419. '*Gur*' samples indicated that non-protein nitrogen was high (42·9 per cent) in Co. 419 than in Co. 527 (19·6 per cent) '*gur*'. Also the colloidal material in the '*gur*' of former variety was 5·5 per cent against 3·5 per cent in '*gur*' from Co. 527. In consequence the '*gur*' of Co. 419 was hard, brown in colour and moderately crystalline as compared to yellowish, very hard and highly crystalline '*gur*' from Co. 527. The juices of the two varieties showed similar differences in colloids and non-protein nitrogen.

Prashar (1956) examined a large number of juice samples of mixed commercial varieties and the behaviour of different constituents of cane juice during the process of clarification in a few selected sugar factories in different tracts of U.P. These data have been compared to the data from different sugar manufacturing countries. He observed that ash percentage in raw juice in India is fairly high and varies from 0·4 to 0·7 per cent as against the range of 0·2 to 0·6 per cent. In ash the phosphate content varies from 11 to 17 per cent which is higher than in juices of other countries. The percentage of chloride ranges from three to five per cent in ash which is lower than in other countries while the sulphate content range is extremely high i.e., 35-38 per cent in ash. The calcium content in ash of raw juice varies from four to five per cent which is slightly lower than in Cuba or Louisiana but higher than in Java. Ash contains 23-24 per cent total alkalies as against 45-50 per cent in raw juice in other countries. Iron and alumina constitute 8 to 11 per cent in ash. These are appreciably higher than in juice of P.O.J. 2878 in southern India which contain low amounts of phosphate and create difficulties in settling of treated juices. In North Bihar juices of Co. 313 gave high mud volume and this caused difficulties in filteration and thereby reduced crushing capacity of sugar factories by 15 to 20 per cent. This was due to fairly high percentage of alcohol precipitate non-sugars (colloids) which was approximately 50 per cent more than in other cane varieties. The fractional liming method at 50°C. gave better results in settling of juices than simultaneous liming at 160°F. (71·6°C.). Best results were obtained if the quantity of milk of lime corresponding to a pH value of 10·60 was used. Mathur and Mukherjee (1956) have shown that for juices which contain lower ash content as in Bombay-Deccan the ion-exchange method of clarification is better suited than standard sulphitation or double carbonation processes. The rise in purity of Bombay-Deccan juices on ion-exchange treatment are of the order of 7·5 units and 6·6 per cent additional sucrose is recoverable from de-ionised juice.

Besides the normal constituents of the cane juice, it further contains, in suspension, fine bagasse particles, clay together with chlorophyll and albumin. These suspended impurities sometimes are a source of considerable trouble in the mill for they are not easily cleared off quickly in the process of filteration.

From the figures of routine analysis two factors, the purity coefficient and the sucrose/glucose ratio of the variety are worked out. It is regarded that higher these coefficient and ratios are, the better is the variety suited to the manufacturing processes. In a sense it is true also. High purity co-efficient indicates that the proportion of dissolved substances to sucrose is high. Alternatively it indicates that non-sugars and reducing sugars are less and will be easily eliminated in clarification.

Summary

The introduction of Coimbatore seedlings provided a firm basis for the establishment of the sugar industry. The varieties selected and introduced generally have very desirable features from the aspect of milling, fuel value, characters of raw juice for clarification and crystallization. The introduction of some of the varieties raise special problems.

The variety suitable for milling department should not show heavy disintegration of bagasse during milling and should not have tendency to slippage at the rollers. Such characteristics are absent from varieties which have broad, squarish cells having lesser number of cell walls per unit volume. The bagasse blanket has cohesion and less brittleness in its structure due to smaller number of vascular bundles.

Besides high fibre content, which is the chief characteristic of superior fuel variety, the structure of the fibre should be such that it is superior in 'steam raising' value. The bagasse fibre is less porous and more dense.

The raw commercial juices in sugar factories in the north India have high content of phosphate and sulphate ions but low content of chloride. These can be easily clarified by the process of fractional liming. In southern India the raw juices have low phosphate content which present difficulties in clarification. The ion-exchange method is more suitable than sulphitation or double carbonation processes which lead to 6·6 per cent additional sugar. This process has not yet been given trial on a factory scale.

For '*gur*' manufacture the characters of the cane should be such that extraction of juice is high, and the juice contains less of non-protein nitrogen and colloidal substances. This would conduce to good setting of '*gur*' and fine yellow colour of the material.

REFERENCES

Alvarez, A. S. (1938). Chemical composition of varieties POJ 36 and 213. *Revista Ind. Agricola Zucuman*, **27** (4 and 6): 111, 122.

Anonymous (1931). *Proc. Second Conf. Queensland Soc. of Sugarcane Tech.*

Arceaneux, G. (1945). Generalised factors for computing varietal yields of sugar from results of field tests with sugarcane. *Sugar. Bull.*, **23** (21): 186-91.

Browne, C. A. and Zerban, F. W. (1941). 'Physical and chemical methods of sugar analysis', New York, 1086.

Davis, J. G. (1939). A contribution to raw sugar clarification. *Proc. Sixth Congress Internat. Soc. Sug.cane Tech. Louisiana.*

Daymond, G. C. (1942). Varietal milling results in Natal. *Proc. Sixteenth Congress S. African Sugar Tech. Assoc.*: 37-42.

Harloff, W. H. Th. and Schmidt, W. (1913). 'Plantation white sugar Manufacture', London.

Fort, C. A. and Walton, C. F. (1932). Sugar producing characteristics of different cane varieties. *Sugar Bull.*, **11** (4).

Heriot, T. H. P. (1920). 'The Manufacture of sugar from the cane and Beet.', 349.

Khanna, K. L. and Chacravarti, A. S. (1951). The non-sugars in sugarcane juice and their bearing on clarifying properties. A study in relation to open pan industry. *Proc. Ind. Alad. Sci. Section B.*, **33**: 204.

———— (1955). Researches on technical aspects relating to improvement of the '*gur*' industry in Bihar. *Scientific Monograph Ind. Central Sugarcane Comm.*

Khanna, K. L. and Panje, R. R. (1939). Studies in the rind hardness of sugarcane. *Ind. J. Agric. Sci.*, **9** (1).

Kloppenburg, C. A. (1943). Carbo sulphitation Process. *Indian Sugar*, **6** (10): 383-86.

Kortschak, H. P. (1939). Colloids in the sugar mill. *H. Pl. Rec.*, **43** (1): 33.

Lander, P. E. and Narain, R. (1935). Sugarcane in the Punjab. Part I. *Ind. J. Agric. Sci.*, **5** (2): 213-345.

Mathur, G. P. and Mukerjee, S. (1956). Ion exchange method of cane juice clarification. The effect of ion exchangers on cane juice clarified by different techniques. *Proc. Ninth Congress Intern. Soc. Sug. cane Tech.*, Part II: 381-91.

Mohan Rao, N. V. and Reddy, A. D. (1951). Chemical composition and keeping quality of jaggery from cane grown under swampy conditions. *Proc. First Bien. Conf. Sug.cane Res. & Dev. Workers, India.*: 152-56.

Ness, A. R. (1941). Elimination of the soluble non-sugars during processing. *Abstract Intern. Sug. Jour.*, **43**: 378.

Noel Deerr (1921). 'Cane Sugar', Norman Rodgers, London.

Parthasarathy, S. V. 'Problems of *Gur* in India'. *Ibid.*,: 263-70.

———— and Lakhshmi Kantham (1951). Characteristics of cane varieties and their influence in cultivation. *Proc. First Bienn. Conf. Sug. cane. Res. & Dev. Workers, India*: 37-45.

Prashar, D. R. (1956). Characteristics of Indian cane juices in relation to the behaviour during clarification in the sulphitation sugar factories. *Proc. Ninth Cong. Intern. Soc. Sug. cane Tech.* Part II: 358-69.

Prinsen Geerligs, H. C. (1924). 'Cane sugar and its Manufacture'.

Ramanujam, D. (1956). Influence of structure of cane on the 'steaming' quality of bagasse and on mill work. *Proc. Ninth Cong. Internat. Soc. Sug. cane Tech.*, Part II: 63-69.

Saint, S. J. (1931). Scientific control of 'pan boiling'. *Fourth Cong. Internat. Soc. Sug. cane Tech.*

Soragato, I. (1936). Nitrogen compounds and the technological value of the sugar beet. *Abstract Internat. Sugar Jour.*, **38**: 352.

Srivastava, R. C., Van Der Myden, C. W. P., and Khan, A. R. (1943). Milling Control. *Proc. 10th Conf. Sugar Tech. Assoc., India*: 127-36.

Ueno, T. (1938). Relation of rind hardness to the internal structure of the sugarcane. *Report Govt. Sug.cane Expt. Sta. Formosa*: 21-29.

Walton, C. F. and Fort, C. A. (1932). Variable composition of cane juices and elimination of non-sugars by clarification. *Facts About Sugar*: **10**.

INFLUENCE OF INTERNODE BORER ON THE QUALITY OF JUICE IN SUGARCANE

By

H. David and V. Ranganathan

(Central Sugarcane Research Station, Cuddalore, Madras)

Introduction

THE internode borer of sugarcane (*Proceras indicus Kapur*) is not generally considered to be a pest of major importance in the cane areas in this state as a whole. However, the incidence of this borer is increasing in intensity in certain localities like Pettawaithalai and Nellikuppam Factory areas. The borer commences its activity near about the fourth month and continues its activity till harvest. The life-history of the borer extends from 39 to 57 days. This pest also infests the grass *Saccharum spontaneum* near the cane fields. The damage by the borer is generaly confined to the internode and hence very rarely the attacked shoot dies. This borer has migratory habits and consequently one borer may attack two or three canes or nodes in the same stick. The length bored also varies in different canes and also in different varieties. In this tract where many diseases of sugarcane are prevalent, the internode borer-affected canes are easily accessible for wound parasites like the Pine-apple fungus and subsequently the canes become dried up. Thus the problem becomes all the more aggravated.

Incidence

In South Arcot District, the incidence of this borer is on the increase. Among the three popular varieties of this tract, the variety Co. 449 which occupies a major area is highly susceptible to internode borer attack. In some cases the incidence goes up to even 50 per cent. Observations made on the incidence of borer attack in the different promising varieties at the Central Sugarcane Research Station, Cuddalore showed that some of the varieties, are highly susceptible to internode borer attack while some are less susceptible. The varieties Co. 419, Co. 726, and Co. 997 are highly susceptible while the variety Co. 785 is fairly resistant. However, it was noticed that the intensity of attack varied much in the same variety in different years.

It is noteworthy that the early shoot borer (*Chilotraea infuscatellus Snell*) also occurs as an internode-borer in some cases in grown-up canes, but the percenage of incidence of this borer in canes affected is much less and is genrally within five per cent only. With a view to find out the loss in quality of juice in canes affected by *Proceras indcus*, detailed analysis of juice was done in both the healthy and affected canes and the results are discussed here.

Previous Work on Quality of Infested Cane

It has been reported by Pruthi and Narayanan (1939) that internode borer was most harmful in respect of quality, the canes affected by the borer recording 13·07 per cent sucrose against 16·28 per cent by healthy canes. However, Ramachandra Chari (1951) reported that the internode borer causes greater loss in weight of cane than in the quality of the juice. Doss (1956) who studied the incidence and damage of the different borers in the Nellikuppam Factory Zone reported that " unlike the canes infested by *Scirpophaga*, canes infested by *Proceras* were not very much inferior in quality to healthy canes in any month of planting. " The detailed studies on the influence of the internode borer in the quality of juice in the different promising varieties of cane are presented in this paper.

Materials and Methods

To assess the nature of loss in quality the affected and healthy canes were separated at harvest, crushed and the juice analysed for quality. The analysis was taken up in the two seasons i. e., 1957-58 and 1958-59 in all the promising varieties in the yield trials. The detailed analysis of individual canes attacked by internode borer was also taken up after recording the preliminary measurements like length of canes, number of internodes present, number of internodes affected, length of internodes affected etc. It was noticed that in some of the fields the internode borer affected canes were secondarily affected by pine-apple disease and hence the diseased canes were also analysed separately to find out the degree of loss in quality of juice.

Results and Discussion

Table I gives the sucrose per cent of both healthy and affected canes examined in 1957-58 and 1958-59 seasons. It shows clearly that there is no appreciable decrease in the sucrose percentage of the juice in almost all the varieties. In fact some of the varieties showed even slightly higher percentage of sucrose. The statistical analysis of the data revealed that there was no significant difference in the sucrose per cent of the juice between the healthy and affected canes. The influence of the borer on the quality of juice is uniform in all the varieties. The c.c.s. per cent was also calculated and it was found that the results were the same. The data are furnished in Table II.

Table I

Loss in sucrose per cent due to internode borer infestation

Variety	1957–58 Sucrose % of Juice in		Variety	1958–59 Sucrose % of Juice in	
	Healthy Canes	I.B. Affected Canes		Healthy Canes	I.B. Affected Canes
1. Co. 419	16·2	16·5	Co. 449	15·5	15·5
2. Co. 449	19·1	19·1	Co. 527	16·1	15·8
3. Co. 527	17·5	16·4	Co. 658	18·2	18·1
4. Co. 658	19·6	19·3	Co. 726	13·7	11·3
5. Co. 719	19·8	19·2	Co. 740	14·6	14·5
6. Co. 758	19·3	18·8	Co. 785	16·4	14·6
7. Co. 785	19·0	18·6	Co. 997	19·1	19·0
8. Co. 799	17·9	17·1	Co. 1001	15·7	15·6
Average ..	18·6	18·1		16·2	15·6

Table II

Loss in C.C.S. per cent due to internode borer infestation

Variety	1957–58 C.C.S. %		Variety	1958–59 C.C.S. %	
	Healthy canes	Infested canes		Healthy canes	Infested canes
1. Co. 419	10·98	11·31	Co. 449	10·83	10·91
2. Co. 449	13·48	13·86	Co. 527	11·42	11·04
3. Co. 527	12·36	11·88	Co. 658	13·03	13·48
4. Co. 658	14·19	13·90	Co. 726	9.30	6·87
5. Co. 719	14·32	13·78	Co. 740	9.91	9·95
6. Co. 758	13·84	13·36	Co. 785	11·57	10·02
7. Co. 785	13·73	13·34	Co. 997	13·79	13·69
8. Co. 799	12·83	12·05	Co. 1001	11·02	11·25
Average ..	13·22	12·93	..	11·36	10·90

Not significant — Not significant

Subsequently in the 1958-59 season the internode-borer affected canes were separated as one node-affected, two-nodes affected and three nodes-affected canes and the quality of juice analysed in each case. It was found that there was significant lowering of quality of juice only in the case of three internode affected canes. The data are furnished in Table III. It was also noticed that there was no difference in the case of early affected and late-affected canes among one node affected canes.

TABLE III

Loss in quality, due to internode borer with reference to the intensity of infestation

Age. 11-12 month (1958-59) Variety Co. 449

No. of internodes affected	NODE BASIS						LENGTH BASIS					
	Per cent of canes in each case.	Length of cane in inch.	No. of internodes.	Length bored in inchs.	Wt. of canes in lbs.	Commercial cane Sugar per cent.	Per cent length of borer infestation on the total length of cane.	Length of cane in inches.	No. of internodes.	Length bored in inches.	Per cent of cane in each group.	Commercial cane Sugar per cent
HEALTHY CANES	57	134	30	0	4·30	10·84±0·27	Healthy	134	30	..	57	10·84±0·27
One internode bottom affected	10	128	29	3·1	4·05	10·50±0·24	Below 5 %	127	28	3″	30	10·47±0·25
One internode top affected	13	129	29	3·8	3·90	10·56±0·23	6-10 %	126	28	8″	8	10·09±0·50
Two internodes affected..	13	135	30	6·3	3·40	10·39±0·41	Above10 %	112	27	18·0″	5	8·43±0·68
Three internodes affected	7	126	27	15·8	3·40	9·94±0·63						

Difference in C.C.S. per cent between healthy and three-node affected significant at P=0·05

Difference between healthy and canes affected by more than 10 per cent length significant at P=0·05 per cent.

The percentage of length of canes affected was also noted and the infested canes were classified as attacked below five per cent, six per cent to ten per cent and above ten per cent and the juice quality compared with that of healthy canes. It was noticed that the difference in c.c.s. per cent between healthy canes and canes bored through for more than ten per cent of the total length was significant at a probability level much lower than 0·05.

The analysis of juice of healthy canes, internode-borer affected canes and internode borer plus pine-apple diseased canes revealed that in the case of the latter, the decrease in quality is to a remarkably marked extent, when compared to the previous analysis. The difference is highly significant. The data are furnished in Table IV.

TABLE IV

Quality of healthy canes, borer infested canes and borer infested and pine-apple diseased canes

Variety Co. 449

No.	Particulars	Per cent C.C.S.	Statistical Analysis
1.	Healthy Canes	6·63 ± 0·2406	The difference between groups are significant at probability level of 0·05
2.	Internodes Borer Canes ..	5·62 ± 0·1886	
3.	Internode Borer Affected and Subsequently Pineapple Diseased Canes	0·045	

Conclusions

It is clear from the foregoing, that in the different varieties studied, there was no significant difference in quality of the juice, between healthy and internode borer affected canes when the evaluation was done without reference to the intensity of infestation. However, when the intensity of attack as judged by the number of internodes affected and the length of the cane affected was taken into account, it was noticed that the loss in quality is directly related to the percentage length of cane affected. The correlation co-efficient between them is very high (0·99).

The length bored varied much and depends on the intensity of infestation of borer in the field. It is seen that the loss in quality is significant only when there is high infestation and consequently the length bored by the borer exceeds ten per cent of the total length of the cane. The loss in juice quality is further enhanced by the secondary attack of diseases like pine-apple which gets an easy entrance into the cane through the wound produced by the borer.

Summary

1. There was no significant loss in juice quality due to internode borer attack when the canes were analysed on field scale for their juice quality.

2. There was no appreciable variation in the nature of loss in juice quality in the different varieties examined.

3. The individual analysis of infested canes revealed that the extent of loss in quality is significant when the borer damage extends to more than ten per cent of the total length of the canes.

4. The loss in quality is enhanced by the secondary attack of diseases like pine-apple in the standing canes.

Acknowledgment

Our thanks are due to the Sugarcane Specialist, Cuddalore for providing necessary facilities to take up this study and also to the Indian Central Sugarcane Committee for partly financing the scheme.

REFERENCES

Doss, S. V. J. (1954) *Proc. Second Bien. Conf. of Sugarcane Res. and Dev. Workers.*

Khan, M. Q. and Murthy, D. V. (1954). A Plea for greater attention of Internode Borer in Sugarcane. *Second Bien. Conf. of Sugarcane Res. and Dev. Workers*—Papers presented.

Nagaraja Rao and Chandy, K. C. (1957). Studies on the Incidence of Sugarcane Borers. *Ind. J. Sug. Res. & Dev.*, Vol. **II**, pt. 1.

Ramachandrachari, C. (1951). *First Bien. Conf. of Sugarcane Res. and Dev. Workers*—Papers presented.

Siddiqui, S. A. and Agarwal, R. A. (1957). The First Record of Heavy Infestation of Proceras indicus in U.P. *Ind. J. Sug. Res. & Dev.* Vol. **II**: pt. 1.

EXTERNAL ANATOMY OF *LEUCANIA (CIRPHIS) UNIPUNCTA* HAWORTH (NOCTUIDAE: LEPIDOPTERA)

By

DHAMO K. BUTANI*

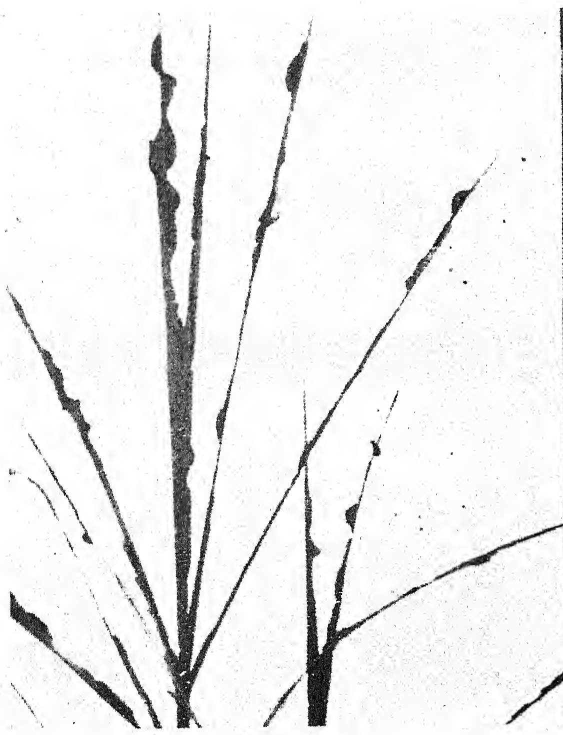
(Sugarcane Research Institute, Pusa, Bihar)

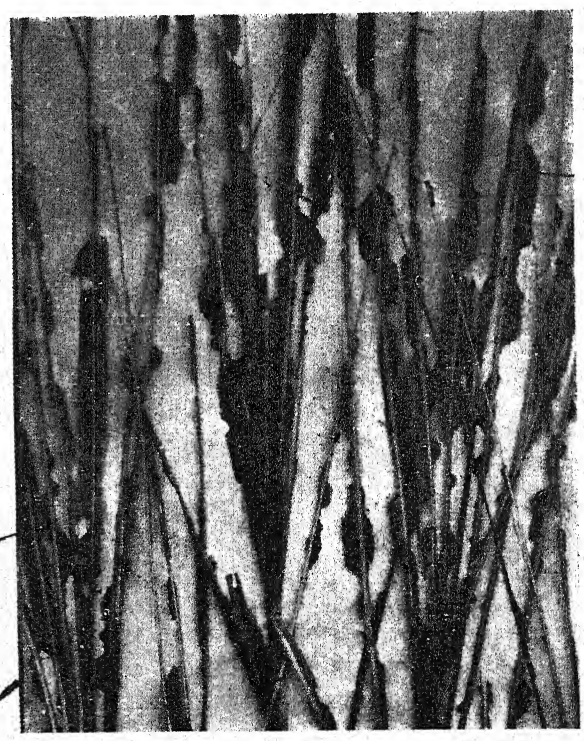
INTRODUCTION

LEUCANIA (*Cirphis*) *unipuncta* Haw. (*saccharivora* Butl.) or the armyworm, as it is commonly known, is essentially a pest of cereals and grasses all over the World. In India it has been reported as one of the major pests of rice (Narayanan, 1953). Wagle (1951) and Butani (1955) reported it for the first time on sugarcane from Bombay and Bihar respectively. Box (1953) recorded its occurrence on sugarcane in Indo-China, Java, Formosa, Philippines, Queensland, Fiji, Hawaii, U.S.A., Mexico, Cuba and British Guinea. Its caterpillars are voracious feeders and in severly infested fields, the crop is completely defoliated and reduced to mere midribs (Plate I).

Inspite of its wide distribution, no information is available about its anatomy or of related species which is of immense value to the Entomologists. An attempt has, therefore, been made in the present paper to incorporate the findings of anatomical studies on this insect conducted at Sugarcane Research Institute, Pusa, Bihar.

PLATE I





Defoliated Crop of Sugarcane

*Bihar Agric. College, Sabour, Bihar.

Material and Method

Anatomical studies were confined to the larvae, pupae and adults reared from the field collection of larvae. The usual method of KOH maceration and basic fuchsine staining was followed for preparing the permanent mounts.

For study of chaetotaxy, full grown caterpillars were killed in hot water (100° C.) and dissected horizontally between the prolegs, after removing their head capsule. These were then boiled in ten per cent KOH for 12-15 minutes, till they became more or less transparent. Thereafter the usual dehydration was done by passing these through various grades of alcohol and staining in basic fuchsine prepared in 90 per cent alcohol. These were then mounted in xylol-balsam after clearing the same in clove oil. The camera lucida drawings of full mounts were prepared and wherever necessary microphotographs were also taken. To ensure that none of the setae was lost during the process of mounting, the camera lucida drawings were compared with live specimens of full grown larvae, anaesthetised with chloroform.

External Anatomy

Larva

Young larva is pale green in colour and crawls somewhat like a semilooper till it is about 20-25 mm. long; full grown larva is cylindrical in shape measuring on an average 44·5 mm. in length and 3·6 mm. in breadth (Plate II, fig. 1). It is dark greenish-brown in colour with four dark longitudinal stripes on either sides of the mid-dorsal line of the body. The first one which is dark-greenish is situated dorso-ventrally; starting from the dorsal side, it covers approximately one-third of the ventral side, leaving a narrow, uneven whitish stripe right in the centre of dorsal body region bordered by its counterpart on the other side. Next to this stripe are three other stripes of more or less equal width. The first one is pale greenish-brown in colour; the middle one dark greenish-brown reaching upto the spiracles and the third one light brown in colour extending upto the prolegs.

Plate II

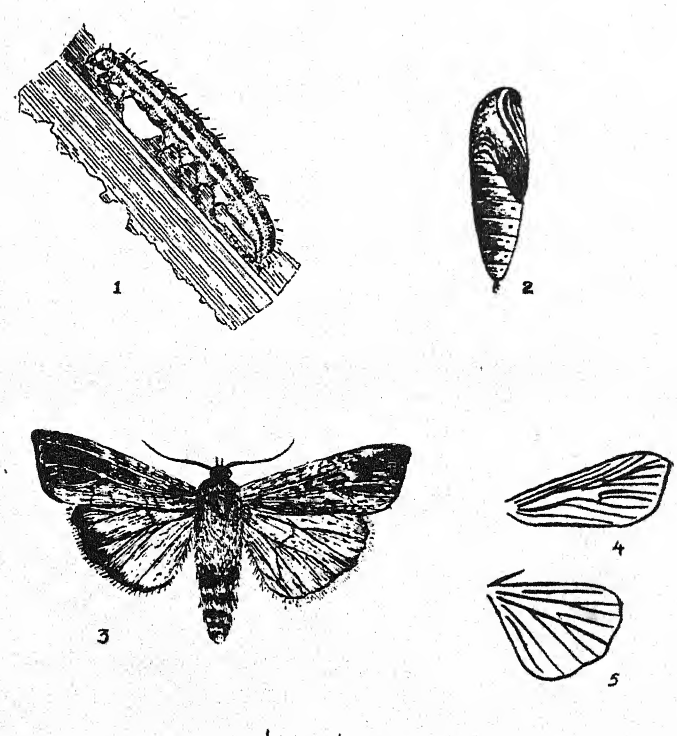


Fig. 1. Full grown larva Fig. 2. Pupa Fig. 3. Adult moth
Fig. 4. Fore wing Fig. 5. Hind wing

Head

The head of the full grown larva is prominent, well developed and proganthous. It is smooth and shiny being dark reddish-brown on the vertex and dark brown distally. The vertex is deeply incised while the cervical shield, which is devoid of any setae is well chitinised and light brownish in colour. The adfrontal sclerites are long and slender, bordering on each side of the lower part of adfrontal sutures and whole of the frontal sutures. Ocelli are sessile and six in number situated behind the antennae. The antennae are short and three jointed. The mandibles are very strong and dark brown in colour, with six dentitions of which the lower three are comparatively more sharp.

Thorax

It consists of the usual three segments. Pro-thorax is the smallest, bearing the prothoracic shield and a pair of spiracles. Each segment carries a pair of five jointed legs directed forward, with tarsus having a single curved claw.

Abdomen

It consists of ten visible segments, the first seven being uniformly broad while the last three gradually tapering and ending in dorso-ventrally flattened epipygium. The segments, III, IV, V, VI and X, each bear a pair of prolegs. These prolegs are thick, fleshy more or less conical in shape the apex being flat and beset with uniordinal crochets arranged in meso-series. Each of the first eight segments also carry a pair of oval elongated spiracles. The spiracles of segments I to VII are of equal size, whereas those of segment VIII are one and half times bigger than the rest.

Chaetotaxy

The larval chaetotaxy of various insects has been studied in detail by many workers all over the world. Dyar (1895 and 1896) was first to suggest a nomenclature for the various setae. This nomenclature, which was later followed by Forbes (1910) consisted in giving Roman numerals to the setae numbering the cranial setae from hind margin forward and in case of thoracic and abdominal setae from mid-dorsal line downwards. Fracker (1915) named the setae using Greek alphabets. Dampf (1910) changed the whole terminology and pointed out that the setae always occur in definite groups and as such he named the groups of setae and not the individual setae. Heinrich (1916) again used the Roman numerals and named all the setae except those of vertical group. He also redefined Dempf's dorso-lateral group and later (1918 and 1921), he made some slight changes and simplified the abbreviations used in naming the setae of different groups. Ripley (1923) suggested a nomenclature based on the terminology of Forbes (*loc. cit.*) and Dyar (*loc. cit.*) as he did not agree with the nomenclature adopted by Dampf (*loc. cit.*) and Heinrich (*loc. cit.*). Cerasimov (1935) accepted the terminology of Heinrich (*loc. cit.*) and added to it the setal names for the vertical group. Trehan and Butani (1950) adopted a terminology after Kinoshita and Kawada (1932) for the head capsule and after Fracker (*loc. cit.*) and Dyar (*loc. cit.*) in cases of thorax and abdomen respectively. They also gave their arbitrary names in case of antennae and mouth parts as these setae were not named by the earlier workers. Hinton (1946) completely revised the nomenclature. He classified the setae into two groups, microscopic or propriceptors and long or tactile setae according to the function of the setae. His terminology consists of naming the setae according to their respective groups.

In the present paper the terminology of Hinton (*loc. cit.*) has been adopted (Plate III).

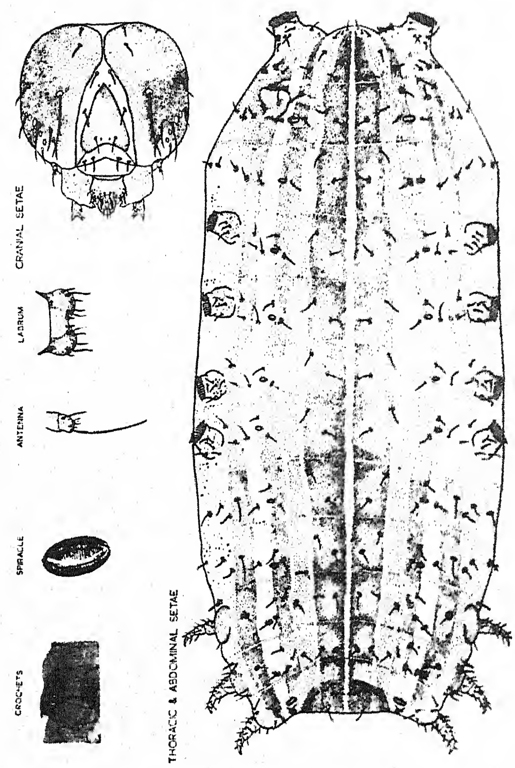
Cranial setae

Each epicranial plate bears 13 setae. On the vertex lie two setae, V_1 and V_2, the former being slightly longer than the latter. One seta each of the lateral and posterior group is present more or less in the centre of the epicranial plate. P_1 which is conspicuously the longest seta is placed nearer the adfrontal suture, whereas L_1 is far away from the adfrontal suture. All the three anteric setae, A_1, A_2 and A_3 are present, situated just behind the ocelli. Of these A_3 is the longest. Near the 1st and 4th ocellus are situated ocellar setae 0_1 and 0_2 respectively, the latter being longer than the former. The remaining four setae, viz., ocellar seta O_3 and the sub-ocellar setae, SO_1, SO_2 and SO_3 are situated on the ventral side and as such are not visible in the diagram laso.

The adfrontal sclerite bears two pairs of setae, AF_1 and AF_2 and a pair of sensoria AFa. Seta AF_2 lies near the angle made by two adfrontal sutures. Near the angle made by the two adfrontal ridges is the adfrontal sensorium Afa, which is nearer to AF_2 than to AF_1. AF_1 lies in the centre of adfrontal sclerite in between the adfrontal ridge and adfrontal suture. Frons are beset with one pair of frontal setae F_1 and one pair of frontal sensoria Fa. Seta F_1 lies nearer the adfrontal ridge and the sensoria Fa close to each other in the middle of the sclerite near the base. The clypeus bears two pairs of clypeal setae, C_1 and C_2

on either side. Seta C_1 lies near the angle made by the adfrontal sutures with the anterior margin of the clypeus and is shorter than C_2. Seta C_2 is situated caudad from C_1.

PLATE III



Antennae* bear three setae each, on segment II (t_1, t_2 and t_3) and III (k_1, k_2 and k_3), there being no seta on segment I. Seta t_1 is conspicuously the longest of all the setae. Labrum* bears 12 setae, six on either side (l_1, l_2, l_3, l_4, l_5 and l_6), lying adjacent to the anter or margin.

Thoracic setae

These are borne on weakly chitinised, fulgidus, rounded tubercles which are arranged in a definite manner.

Prothoracic shield bears five setae on either side. XD group of setae which are present only on prothorax, consists of XD_1 and XD_2, both situated near the cephalic margin. XD_1 which is comparatively longer than XD_2 is situated directly above the latter. Dorsal setae D_1 and D_2 are situated on the caudal side of the shield, D_2 being near the caudal margin. Sub-dorsal seta SD_1 is wanting, whereas SD_2 is present, situated near the caudal margin, and in a vertical line with D_1. Lateral setae L_1 and L_2 are borne on the same tubercle, situated between the spiracle and the cephalic margin, being more towards the latter. L_1 slightly longer than and separate from L_2, situated slightly above the latter. L_3 is absent. Sub-ventral setae SV_1, SV_2 and SV_3 are present. These are more or less equal in size, arranged in a triangular fashion near the caudal margin and are situated in between the spiracle and the base of the thoracic leg. Ventral seta V1 is situated at the base of thoracic leg, nearer the mid-ventral line and widely separated from the sub-ventral setae.

Mesothorax and Metathorax, each bear 18 setae, nine on each side. Dorsal setae D_1 and D_2 are in vertical line, D_1 being more dorsal. Sub-dorsal setae SD_1 and SD_2 are also in vertical line, SD_1 being directly below SD_2. Lateral setae L_1 and L_2 are more or less in a horizontal line whereas seta L_2 is situated below L_1. There is only one sub-ventral and one ventral seta, SV_1 and V_1. Both these setae are widely separated from each other, V_1 being near the mid ventral line. The thoracic legs have each a whorl of setae on femur and a few stray ones on other segments.

*The terminology adopted after Trehan and Butani (1950).

Abdominal setae

Like thoracic setae, these setae also are borne on weakly chitinised tubercles. Segments I and II bear the same number of setae in more or less similar position. Each of these segments bear 18 setae, 9 on either side. Dorsal seta D_1 is situated antero-dorsad from seta D_2. There is only one sub-dorsal seta, SD_1 situated above the spiracle. Lateral setae, L_1, L_2 and L_3 are widely separated from each other, L_1 is situated posterior to the spiracle, L_2 is just below the spiracle being antero-ventrad to L_1 whereas L_3 is still further down being postero-ventrad to L_2. Only 2 sub-ventral setae, SV_1 and SV_2 are present, the latter being antero-dorsad to former. One ventral seta V_1 is as usual present, near mid-ventral line.

Setal arrangement on segments III to VI is identical to those on segment I and II in respect of dorsal, lateral and sub-ventral setae, SV_2 being just at the bottom of proleg. The ventral seta V_1, which in case of thoracic segments is situated between the thoracic legs is not there in between the prolegs. There are 4 setae on each proleg, of which one may be V_1.

Segment VII bears 8 setae on either side. Dorsal seta D_1 is situated antero-dorsad to D_2, the latter being near the posterior suture. Sub-dorsal seta SD_1 is directly above the spiracle. Below the spiracle are lateral setae, L_1, L_2 and L_3. Sub-ventral seta SV_1 is in vertical line with L_3, followed by ventral seta V_1, which is as usual near the mid ventral line.

Segment VIII have 9 setae on either side. The position of dorsal setae (D_1 and D_2), sub-dorsal seta (SD_1), vertical setae (L_1, L_2 and L_3) and sub-ventral seta (SV_1) is same as in case of segment VI. Seta SV_2 is near SV_1 and directly below it and the ventral seta V_1 is near mid-ventral line.

Segment IX bears only six setae on either side; two dorsal (D_1 and D_2), one sub-dorsal (SD_1), one lateral (L_1), one sub-ventral (SV_1) and one ventral V_1.

The anal segment X bears 8 setae on each side, beside 4 on anal proleg. As it is rather difficult to study the arrangement of setae on this segment, the nomenclature given may be treated as arbitrary and should not be considered for taxonomical studies. The two setae near the dorsal line are D_1 and D_2. The lateral setae L_1, L_2 and L_3 are situated along the caudal margin whereas SD_1 situated in between L_2 and L_3 is very much near cephalic margin. SV_1 and V_1 are near the mid-ventral line, the latter being nearer.

For sake of comparison, the nomenclature suggested by various workers for the tactile setae present on thorax and abdomen has been tabulated below.

Distribution of tactile setae on a full grown larva of Leucania unipuncta *Haw.*

Forbes (1910)	Fracker (1915)	Gerasimov (1935)	Hinton (1946)	* = Present x = Absent
		Prothorax		
X	Alpha	X	XD_1	*
IX	Gamma	IX	XD_2	*
I	Beta	I	D_1	*
—	Delta	—	D_2	*
II	Epsilon	II	SD_1	x
III a	Rho	III a	SD_2	*
IV	Kappa	III	L_1	*
V	Eta	IV	L_2	*
—	Theta	V	L_3	x
VII a	Pi	VI	SV_1	*
VII b	Nu	VII a	SV_2	*
VII c	Tau	—	SV_3	*
VIII	Sigma	VII b	V_1	*

Forbes (1910)	Fracker (1915)	Cerasimov (1935)	Hinton (1946)	* = Present x = Absent			
		Mesothorax and Metathorax					
I a	Alpha	I	D_1	*			
I b	Beta	II	D_2	*			
II a	Rho	III	SD_1	*			
II b	Epsilon	III a	SD_2	*			
IV	Kappa	IV	L_1	*			
V	Eta	V	L_2	*			
—	Theta	VI	L_3	*			
VI	Pi	VII a	SV_1	*			
VII	Nu	—	SV_2	x			
VIII	Sigma	VIII	V_1	*			
		Abdomen					
				Segments I, II & VIII	Segments III-VI	Segments VII & X	Segment IX
I	Alpha	I	D_1	*	*	*	*
II	Beta	II	D_2	*	*	*	*
III	Rho	III	SD_1	*	*	*	*
III a	Epsilon	III a	SD_2	x	x	x	x
IV	Kappa	IV	L_1	*	*	*	*
V	Eta	V	L_2	*	*	*	x
VI	Mu	VI	L_3	*	*	*	x
VII a	Pi	VII a	SV_1	*	*	*	*
VII b	Nu	VII b	SV_2	*	*	x	x
—	Tau	VII c	SV_3	x	x	x	x
VIII	Sigma	VIII	V_1	*	?	*	*

? In case of abdominal segments III to VI, seta V_1 is said to be situated on the proleg, i.e. out of the four setae on each proleg, one is said to be seta V_1; this however, needs further confirmation.

Pupa

Pupa is of 'Obtect' type, having all its appendages firmly glued to the body wall. It is dark brown in colour and measures on an average 25 mm. in length. Blunt at the head, it tapers sharply towards the caudal end. Labial palpi are present and the cremaster bears hooked setae (Plate III, fig. 2).

Imago

The original description as given by Hampson (1894) is reproduced below: " Pale brick-red or very pale brown and irrorated with dark specks and blotches. Fore wing with slight traces of the orbicular and reniform stigmata; a minute white speck at lower angle of cell with a black speck inside it; fairly prominent postmedial and marginal series of black specks, the former curved; an indistinct oblique dark apical streak. Hind wing pale suffused with fuscous, in the red specimens less suffused towards base. Underside of hind wing sometimes with faint cell-spot and postmedial series of specks. *Hab.* Universally distributed. *Exp.* 40-50 millim."

This description is too brief and describes only the external appearance of wings. As such necessity was felt to study the external anatomy of imago in detail and a complele account of the same along with wing-venation is furnished in the following paragraph.

Imago is a medium sized, stout, pale-brown moth, with sexual differences well marked. It has a spiral proboscis and minute maxillary palpi. Thorax is concave and well wrapped in fawn coloured scales. Mesothorax is biggest, consisting of a c onglomeration of various sclerites. Legs are uniformly clothed in pale brown scales. Tibia is well developed, its calx having a pair of calcaria. Middle pair of legs have all segments comparatively larger than the corresponding segments of fore and hind legs. Tympanal organs are present in metathorax. The abdomen has only first seven segments visible, whilst segments VIII, IX and X are telescoped and invaginated in segment VII. Spiracles are situated on the first seven segments, and are clothed in concolouration scales as that of thorax. Wing expanse is 42-52 mm. (Plate II, fig. 3). Fore wing long and narrow, approximately three times as long as maximum width, apex a little less than right angle, apical margin straight with anal angle rounded and approximately a right angle (Plate II, fig. 4). Its colour varies from pale brown to dark dusky fawn irrotated with dark specks and blotches with a small single prominent white speck in the centre near the lower angle of the cell. Hind wing is pale suffused with fuscous. Frenulum is present (Plate II, fig. 5). The wing venation in the fore and hind wings is not identical. The specialization is by atrophication rather than addition of veins. Costal vein in fore wing is absent but sub-costal is present and unbranches. Vein R_1 emerging from the middle of the cell extends beyond it while vein R_3 terminated in the apical angle and veins R_4 and R_5 bend down towards the apical margin. M_1 is distinctly separate and starts from the upper angle of the cell. M_2 approximates basally to vein M_3 which arises from the lower angle of the cell. M_4 is distally fused with vein Cu_{1a}, vein Cu_2 being absent. There is only one anal vein present. In hind wing vein $Sc+R_1$ is fused with vein R_5 bust only at one place thus forming a small additional cell near the base of the wing. vein R_5 is reduced to a single vein. Vein Cu_2 is also absent here but two other anal veins are present.

ACKNOWLEDGMENT

The author is gratefully indebted to Mr. K. L. Khanna, Director, Sugarcane Research and Development, Pusa, Bihar, Retired, for his kind guidance and providing the necessary facilities.

REFERENCES

Box, H. E. (1953). "List of sugarcane insects". *Commonwealth Inst. Ent.*, London.
Butani, Dhamo, K. (1955). "Control of an outbreak of the Army worm (*Cirphis unipuncta* Haw.) on sugarcane at Pusa, Bihar, 1953." *Indian J. Ent.*, **17** (1): 133-36.
Cerasimov, A. M. (1935). "Zur Frage der Homodynamie der Borsten von schmetter lingsraupen." *Zool. Ann.*, **112**: 177-94.
Dampf, A. (1910). "Zur Kennting gehasetragender Lepidopteren larven." *Zool. Jl.* (suppl.), **12**: 513-608.
Dyar, H. G. (1895). A classification of Lepidopterous larvae." *Ann. N.Y. Acad. Sci.*, **8**: 194-232.
———— (1896). "Note on the head setae of Lepidopterous larvae with special to the appendages of *Phora melsheimenii*." *J. N. Y. ent. Soc.*, **4**: 92-93.
Forbes, W. T. M. (1910). "A structural study of some caterpillars." *Ann. ent. Soc. Amer.*, **3**: 94-132.
Fracker, S. B. (1915). "The classification of lepidopterous larvae." *Illin. Biol. Monogr.*, **2**: 1-169.
Hampson, G. F. (1894). Fauna of British India. *Moths.*, **2**: 275-76.
Heinrich, C. (1916). "On the toxonomic value of some larval characters in the lepidoptera." *Proc. ent. Soc., Washington*, **18**: 154-64.
———— (1918). "On the lepidopterous genus *Opostega* and its larval affinnities." *Ibid.*, **20**: 27-38.
———— (1921). "Some lepidoptera likely to be confused with the pink boll worm." *Jl. agric. Res., Washington*, **20**: 807-36.
Hinton, H. E. (1946). "On the homology and nomenclature of the setae of lepidopterous larvae: with some notes on the phylogeny of the lepidoptera." *Trans. R. ent. Soc. Lond.*, **97**: 1-37.
Kinoshita, S. and Kawada, A. (1932). "A revision of rice borers and their distribution." *J. Imp. agric. Expt. Sta., Japan*, **2** (1): 97-104.
Narayanan, E. S. (1953). "Pests of Paddy and their control." *Indian Fmg.*, **3** (5): 8-13.
Ripley, L. B. (1923). "The external morphology and post-embryology of *Noctuid larvae*." *Illin. biol. Monogr.*, **8**: 169.
Trehan, K. N. and Butani Dhamo, K. (1950). "Systematic position of *Chilo zonellus* Swinhoe and chaetotaxy of its larvae." *Indian J. agric. Sci.*, **20** (1): 79-85.
Wagle, P. V. (1951). "Army worm on sugarcane." *Proc. 1st. Bien. Conf. Sug. Res. & Dev. Workers, Coimbatore*, Pt. II-3: 12-13.

JAGGERY (GUR) MAKING IN ANDHRA PRADESH

By

T. VENKATAPATHI and N. V. MOHAN RAO

Sugarcane Research Station, Anakapalle, Andhra Pradesh

INTRODUCTION

ANDHRA Pradesh produces annually about four lakhs tons of Jaggery out of which about 65,000 are exported outside the State. It is one of the ancient decentralised cottage Industries consuming over 65 per cent of the cane production in the State. It plays a dominant role in the economy of the cultivator besides influencing the production of Sugar to a marked extent.

The quality of *Gur* is decided mainly by its colour, taste, consistency, structure and keeping quality which are the main Physical Characteristics. The best quality of Jaggery should possess a very light or golden yellow colour, should be very hard to touch giving a metallic sound, crystalline in structure and should keep well for a long time in storage. The chemical composition of Jaggery and its quality are dependant on the composition of juice from which the *gur* is made. They depend on a number of factors namely, soil, climate, variety, nature of cultivation, the stage of maturity at harvest and the method of preparation of *gur*.

The Government of India have called for the proposals " to make the *gur* more pleasing to the eye, more clean and better marketable ", (1) Lighter yellow or golden yellow colour goes with good quality jaggeries. It depends upon the variety of cane and other factors including clarification methods.

Use of bleaching agents like " hydros " or " hypo " is not desirable as the lighter colour gained by such use is not of long standing and the addition of clarificant is supposed to impart harmful nutritional qualities to the Jaggery.

Cleanliness

Jaggery is nothing but the concentrated cane juice with the impurities removed. The impurities present in the juice are generally of two types—One in solution and the others in suspension. The suspended impurities can be removed by mechanical methods such as filtration. Those in solution cannot be removed unless they are precipitated. They are generally coagulated during the process of manufacture of Jaggery by the heat as well as by the action of some clarificants. The coagulated mass rises to the surface during the preliminary stages of boiling when they are removed by perforated ladles. The Chemical clarificants added to the juice to effect best coagulation should not be of such type as one harmful to human consumption and they should not affect the taste or smell of the final product.

Market

Jaggery is manufactured in different shapes in the different districts. In the Anakapalle area it is made into bucket shaped moulds while in Godavari district it is cast into slabs. Chittoor produces *gur* in ball shape while Hindupur supplies the commodity in small pellets, Telangana region prepares in cylindrical form. The different shapes of the Jaggery and their marketable value in different markets of the country as also their influence on the keeping quality and the facilities for despatch are to be investigated.

Packing and Storage

Jaggery from Anakapalle is packed in hessian cloth and exported outside in wagons or lorries. After the onset of monsoon the Jaggeries absorb moisture and become soft and run into molasses. Such loss in storage is estimated to be above 15 per cent. Trials conducted at Anakapalle on the storage methods to evolve a method of packing for best storage indicated that the jaggery moulds wrapped in alkathene film and hessian kept up their consistency and colour while other methods including the control were not to be effective(6).

WORK DONE AT ANAKAPALLE

Varahalu (11) did extensive work on Juice composition in relation to Jaggery quality and classified jaggeries into good and bad ones based on chemical composition and physical features.

Structurally the good jaggeries had an extensive, hard, crystalline internal core covered on the outside by a thin hard and compact envelope which is more deeply coloured than the core while the bad ones had no well defined cores and envelopes. The crystals were well developed and approached the form of an ideal candy type, while the matrix was localised in the envelope in good Jaggeries. Micro structural studies revealed that the impurities had an adverse affect on the size, form, habit and contour of sucrose crystals.

Studies on the moisture relations revealed that good Jaggeries were characterised by openness of texture, greater strength, more texture to hold more moisture in surface solution without yielding and lower amounts of bound water. Recent work indicated that the entire *gur*—moisture relationship and their effects are governed by the equilibrium humidity of the *gur*.

Varahalu also observed that in the case of good Jaggeries the rate of boiling was great and the temperature of setting was high and the time taken for setting was small showing thereby the favourable conditions for nuclii formation and crystal growth.

Finally he established that there was no relationship between the initial purity of the raw juice and the quality of the final product and concluded that the non-sugar organic matter in Jaggery constituted the main controlling factor in determining the crystallinity of sucrose and so the Jaggery quality also.

It was also found (1) that glucose and chlorine were responsible for bad keeping quality. The impurities in appreciable quantities of organic and inorganic constituents in a colloidal and freely dissolved condition made the jaggeries hygroscopic adversely affecting the keeping quality. It was found (1, 4) that the superior quality of jaggery was due to low organic nonsugars, low ash content and higher phosphate content.

pH control

Based on the recommendations of Dutt (8) control of pH of juices during boiling was studied by using B.D.H. indicator papers. The experiments at Sugarcane Research Station, Anakapalle revealed that liming to pH 6·0 in the case of juices from mature canes resulted in good jaggeries (4).

Clarificants

The various clarificants used in *gur* manufacture are classified into two categories, (i) vegetable clarificants and (ii) Chemical clarificants. The vegetable clarificants included Deola (*Hibiscus ficulneus*) Bhendi (*Hibiscus exculentus*), extracts of castor seed and groundnut seed, but none of them were found to be as efficient as lime under Anakapalle conditions (4, 5, 6, 7). The Chemical clarificants tried were lime water, superphosphate, potassium metabisulphite, Potassium biphosphate, lime sucrate, Sodium Carbonate and Sodium bicarbonate. It was found that among the clarificants used lime alone yielded good quality jaggeries. Better quality of *gur* consistent with colour and crystallinity was obtained when 'Lime sucrate' was used as a clarificant. Addition of lime in combination of 10 gms. potassium metabisulphite to about 180-200 lbs. juice resulted in jaggeries of fairly good quality. The use of Sodium salts was found to be definitely harmful to the setting qualities of jaggeries (7). Recent studies indicated that lime sucrate+extract of sukhlai bark have been found to considerably improve quality (10).

The Use of Superphosphate

Superphosphate is commonly used to supplement the juice phosphate in securing better clarification, since it is the most easily available cheap form of phosphate. Superphosphate is acidic in reaction and hence by itself holds little promise in good jaggery making. Superphosphate added to the mature cane juice at 0·05 per cent level as advocated by Bombay was found to affect the setting of jaggery, though the colour was good (5). This may be due to the fact that the acidity of raw juices under Anakapalle conditions is more than in Bombay where super alone was reported to improve colour without affecting the consistency (9). Similar results were reported from the Hospet area in the present Mysore State where pH of the soil and the cane juice were seen to be considerably high. There appears to be a difference in the nature of juice acids at natural pH levels of about 5·2-5·7 bringing about the differential reaction to clarificants (9). This needed extensive study. There was a poor setting when the superphosphate was alone added in the case of immature and deteriorated juices (5, 6). For 'immature' juices though there was setting, the jaggery was soft when compared to ordinary jaggery made with the use of lime. Studies were conducted (5) to see if the hardness due to lime treatment and colour improvement due to superphosphate could be achieved by a judicious combination of both, especially under adverse conditions such as immature and deteriorated cane when high liming has to be resorted to for proper setting.

In the case of immature juices when the juice was limed upto 7·4 pH and delimed to pH 6·4 by addition of superphosphate solution the jaggery was golden yellow. But the *gur* was not very sweet and did not present any crystalline strutcure (5, 6, 7). With mature juices the best jaggery was obtained when the juice was limed to 7·0 pH and delimed to pH 6·0 with superphosphate solution. It was golden yellow in colour,

hard to scratch and very sweet in taste. Better jaggeries were obtained when lime sucrate was used as clarificant. Addition of lime alone to pH 6·0 gave also good jaggery but inferior to that from lime sucrate treatment.

In the case of deteriorated juices jaggeries of good quality was obtained at pH 6·8 when lime sucrate was used as a clarificant. Addition of ¼ lb. of old jaggery powder at the setting stage hastened the setting.

Problem in Gur Making

In the light of the above findings, the chief problems of this industry in Andhra Pradesh fall into three categories namely (1) furnaces and pans (2) clarification and boiling and (3) storage methods.

Quickness in boiling is essential for producing good quality jaggery. The boiling should be done with minimum fuel consumption for which the bagasse and the trash are used. An efficient type of furnace satisfying these two requisites is to be evolved so that the grower is able to handle large quantities of cane for *gur* manufacture. At present the use of 'Sindewahi' furnace and the improved Godavari furnace with double grating is advocated by the cane development department. Wide shallow pans are also recommended for boiling cane Juice to *gur*, facilitate quick boiling and also quick cooling after the change has been brought down.

In the process of clarification of juices for obtaining good jaggeries with colour and hardness, suitable clarificants are to be prescribed based on suitability of such clarificants for a particular tract. The different clarificants added by varying their concentration depend upon the stage of crop at harvest (immature, mature and deteriorated). The chemical composition of juices with a definite range of the constituents responsible for the quality of *gur* has to be fixed for each stage and for each cane growing tract. Hence a detailed study of their aspect conducting a series of trials is essential. The work is under way.

The pH of the juices varies from tract to tract due to varied agronomic factors. Addition of the clarificant to a particular pH level was indicated in many trials so far conducted. Hence control of pH during the process of boiling and addition of different clarificants at different stages of maturity are essential to obtain *gur* of good quality.

Under the storage conditions the keeping quality is to be studied and correlated both with the chemical composition as well as with the changes in atmosphere like, temperature, humidity etc. It is the experience of the cultivators that jaggeries from certain soils or from certain tracts or from certain varieties can keep well for a long time. The factors responsible for such behaviour need investigation.

In the Godavari district jaggery is packed in trash and palmyrah leaf baskets and stored in Pucca godowns. The jaggeries are made into slabs of 2″-3″ thickness under convenient sizes. In the monsoon months the godown is smoked by periodical burning of Paddy husk on the floor to reduce humidity of the enclosed space. This method of storage is popular in the district and found to be efficient. The scientific aspects of such storage requires detailed study. Experiments are being conducted in this line at the Sugarcane Research Station, Anakapalle.

Conclusions

There is a great scope for the improvement of this industry in Andhra State. Jaggeries from different tracts made under different agronomic conditions varied widely in their quality (3). The causative factors responsible for differential behaviour need a survey and a thorough investigaton in the different tracts.

Problems in *gur* making have already been indicated.

The chief markets for the export of *gur* in Andhra Pradesh are, of Anakapalle, Godavari, Chittoor, and Hindupur tracts. The influence of the shape of *gur* made in each tract and the facility for packing, export and on the keeping quality need careful investigation. Work on the above aspect is being carried out.

In the recent years, there is a demand in the international market for Indian *gur*. The *gur* is to be exported in ships under high humid conditions on the sea and a special study is also essential for its storage. Previous experience on such an export necessitated a thorough investigation and certain chemical standards for such jaggeries are also to be fixed to keep the *gur* in good condition for a long time and to withstand the high humid conditions on the sea so that the name for Indian *gur* is established in the foreign countries.

Acknowledgment

The work forms a part of the scheme financed by the Indian Central Sugarcane Committee, to whom our thanks are due.

REFERENCES

1. Annual Report of the Sugrcane Research Scheme, Madras State at Anakapalle and Gudiyattam (1948-49).
2. ———— (1949-50).
3. ———— (1950-51).
4. ———— (1951-52).
5. ———— (1952-53).
6. ———— at Anakapalle (1953-54).
7. ———— (1954-55).
8. Dutt, N. L. (1950). Report on the Survey of Sugarcane Research and Development in India.
9. Mohan Rao, N. V. and Narasimham, R. L. (1954). *Proc. 2nd Bien. Conf., Jullundur*, Part II.
10. ———— . Sugarcane Research at Anakapalle.
11. Varahalu, T. (1935). Thesis for M.Sc. degree, Madras University.

LODGING IN SACCHARUM SPONTANEUM L.

By

O. P. Nagi and D. N. Mishra

(Sugarcane Research Institute, Pusa, Bihar)

In *Saccharum officinarum* L. lodging has been studied both from morphological and physiological aspects by several workers [Borden (1941-42), Das (1936), Khanna (1941) and Dutt 1954]. In sugarcane lodging has economic importance in as much as its effect on yield and juice quality. In *Saccharum spontaneum* L., however, lodging was reported by Dutt in some of the forms at Coimbatore in 1951-52. During the course of evaluation studies of the forms of wild-Saccharums collected at this institute, some forms of *S. spontaneum* lodged heavily (Plate I) and assumed trailing habit. These forms were studied in some detail especially with regard to their flowering.

The lodging forms viz. N. 33, N. 34, N.R. 3, W.S. 30 and W.S. 32 showed abnormal flowering behaviour in comparison with other erect forms of *S. spontaneum*. Generally the flowering was very sparse and only a few clumps in a plot possessed flowering stalks. The flowering was confined to those stalks which had either somehow escaped lodging or to new shoots thrown out from the basal internodes of lodged stalks. The bulk of the mature stalks in a clump continued their vegetative phase till harvest and showed no trace of floral primordia during frequent examinations of the growing point. Such stalks acquired great lengths (even upto 6·1 meters in one case) and assumed trailing habit.

There was a marked difference in the biometrics of clumps with flowered stalks (flowered clumps) and clumps without flowered stalks (non-flowered clumps). It is quite apparent from Table I that the percentage of flowering is very low in all the lodged forms. Non-flowering in them is associated with increased number and length of stalks and internodes per stalk with decrease in girth. The percentage of flowering bears little relation to the percentage decrease or increase in biometrics of stalks and internodes (intensity of lodging). N.R. 3, however, is an exception to the general percentage increase or decrease in biometrics as shown in Table I and shows little difference between biometrics of flowered and non-flowered clumps. There is increase in girth of the stalks instead of decrease in non-flowered clumps in this particular case.

Table I

Biometrics of flowered and non-flowered clumps in lodged forms of* Saccharum Spontaneum L.

Form No.	Percentage of flowering	Flowered Clump					Non-Flowered Clump				
		Stalk		Internodes			Stalk		Internodes		
		Number	Length (cms.)	Number	Length (cms.)	Girth (cms.)	Number	Length in cms. with percentage increase in bracket	Number with percentage increase in bracket	Length in cms. with percentage increase in bracket	Girth in cms. with percentage decrease in bracket
N. 33	13·8	4·60	228·72	20·25	10·83	·52	28·60	482·85 (110·2)	36·60 (80·5)	12·97 (19·8)	·41 (19·2)
N. 34	7·8	2·65	213·12	17·65	10·50	·54	31·0	364·80 (71·1)	32·40 (83·6)	13·44 (28·0)	·52 (3·7)
N.R. 3.. ..	13·9	1·95	244·25	21·60	12·27	·45	13·95	269·12 (10·1)	23·25 (7·6)	12·52 (2·0)	·48 (−6·2)
W.S. 30 ..	6·4	1·10	199·00	20·00	12·69	·52	24·11	433·69 (117·9)	38·00 (90·0)	15·27 (20·3)	·51 (1·9)
W.S. 32 ..	6·2	1·50	194·77	16·10	14·25	·39	22·50	610·52 (213·4)	44·95 (179·5)	17·72 (24·3)	·38 (2·6)

*Average of 20 readings on stalk basis.

In an experiment of artificial lodging three normally erect forms viz. W.S. 25(S), W.S. 26 and W.S. 29 and one normally lodging form viz. W.S. 32, after being similarly cultured, were subjected to mechanical lodging by means of fixing bamboos across the plant rows making the plants level with the ground surface. It was observed that all the mechanically lodged plants exhibited vigorous tillering at the base. The tendency was more pronounced in case of W.S. 25(S) and W.S. 26 of the erect forms and was lowest in the

PLATE I

FIG. 1. A lodging form

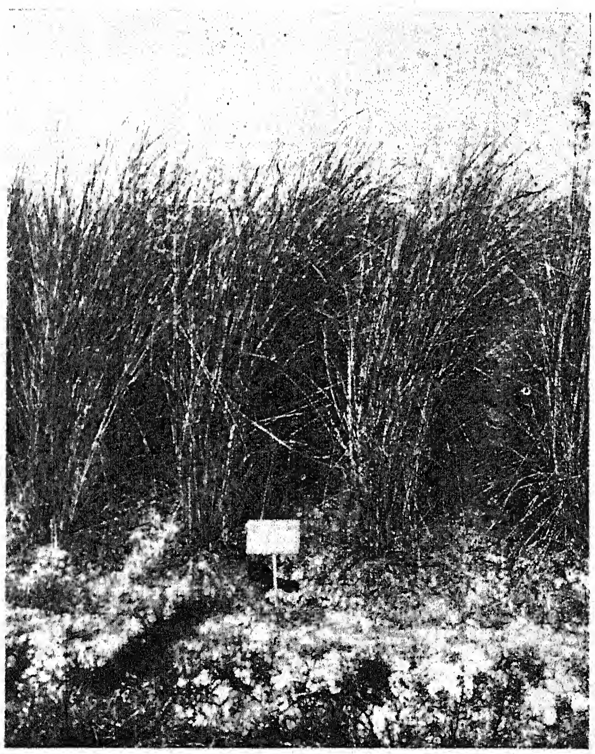


FIG. 2. An erect form

lodging form viz. W.S. 32. All the plants showed a tendency to become erect with tops bending upwards with the growth but fresh bamboos were fixed each month (for a period of four months) to keep the plants horizontal with the ground level till the flowering began. The vigour in tillering was lost in W.S. 29 and W.S. 32 after two months and both the forms assumed lodging habit. The remaining two forms namely W.S. 25 (S) and W.S. 26 were persistently bending upwards and throwing fresh tillers at the base. In erect forms there was also a tendency of buds germinating and throwing out side-shoots which invariably went erect and were continually removed. The observation with regard to date and percentage of flowering, pollen viability, anther dehiscence, size of arrows and height of flowered and unflowered stalks (Table II) showed a difference of two to six days in flowering between all the mechanically lodged forms and their controls. There was a general lowering of the percentage of flowering and size of arrow with virtually no difference in pollen viability and anther dehiscence. Both flowering and non-flowering stalks in mechanically lodged plants of W.S. 29 and W.S. 32 became longer than the controls but increase in length of unflowered stalks which continued their vegetative phase and assumed trailing habit was of a marked degree in W.S. 29 a normally erect variety (Table II). This induced lodging in W.S. 29 was accompanied by a marked lowering in flowering percentage.

TABLE II

Observations on flowering of artificially lodged and control plants*

Form		Date of flowering	Percentage of flowering	Anther-dehiscence percentage	Pollen viability percentage	Size of arrow (inches)	Average height of arrowed stalk (cms.)	Average height of unarrowed stalk (cms.)
W.S. 25 (S)	C ..	30–9–56	100·0	99·0	96·4	24·3 × 13·4	260·2	..
	T ..	4–10–56	53·1	98·0	95·5	22·7 × 11·9	273·5	197·5
W.S. 26	C ..	11–9–56	99·7	100·0	97·5	24·1 × 7·9	259·9	Not taken
	T ..	14–9–56	61·1	99·6	98·8	22·5 × 6·3	241·1	205·4
W.S. 29	C ..	22–9–56	88·5	99·6	91·8	26·7 × 7·8	228·9	Not taken
	T ..	28–9–56	27·4	99·0	91·5	14·5 × 6·0	331·9	569·1
W.S. 32	C ..	18–9–56	93·3	100·0	99·2	27·1 × 7·1	243·8	245·2
	T ..	20–9–56	14·6	99·6	97·8	15·1 × 6·1	282·2	344·8

* Average of all clumps in a row and on stalk basis C stands for control and T for mechanically lodged.

Lodging in *Saccharum spontaneum* L. has been exhibited by only five out of 97 different types of clones collected so far. It could not be produced by the external mechanical stress in two of the three erect clones whereas it was easily reproduced in the lodging type namely W.S. 32. The character for 'erectness' in the majority of the erect varieties is such that it is not easily influenced by external mechanical stress. In W.S. 29, however, which is normally an erect variety and which assumed lodging habits as also expressed by low flowering percentage and marked lengthening of unarrowed stalks, the character for 'erectness' is easily influenced. The characters for 'erectness', or 'lodging' seem to be inherent characters of the clones and the genetical behaviour of the characters, as also the individual and combined effects of external factors including placement of setts, deserves study. Internal factors responsible for lodging have been fully studied in these forms and will be reported elsewhere. Truly erect and lodging forms are distinguishable even at juvenile stages but some like N.R. 3 show no distinction at juvenile stage but lodge later on. The erratic behaviour of N.R. 3 (Table I) and also its partial lodging habit (with some trailing stalks here and there) in subsequent seasons, under similar cultural and environmental conditions, suggest some genetical attribute of the character for 'lodging' in this form.

ACKNOWLEDGMENT

Grateful thanks are due to our Director, Shri K. L. Khanna (now retired) for kindly providing the facilities for the work.

REFERENCES

Bordon, R. J. (1941). *Hawaii Plant. Roc.*, **45**: 241-63.
———— (1942). *Ibid.*, **46**: 39-42.
Das, U. K. (1936). *Plt. Physio.*, **11**: 251-317.
Dutt, N. L. and Ethirajan, A. S. (1954). *2nd. Bien. Conf. of Sugarcane Res. & Dev. Workers, India*, **II**: 12-19.
———— (1951-52). *Ann. Rept. Sug. Dr. Inst., Coimbatore,*
Khanna, K. L. (1941). *Ann. Rept. Cent. Sug. Res. Stn., Pusa, Bihar.*

CROPPING UNDER IRRIGATION

By

R. D. Rege

(Parry & Co. Ltd., Madras)

Objective

PROPER utilisation of available irrigation water depends upon the knowledge of the amount of water consumed in growing each crop and the efficiency with which it can be applied. Such basic information would be essential to the Government in framing cropping patterns for any irrigation project with a view to utilise the water to the best advantage throughout the year. It would be also useful to the agriculturists in planning individual farm systems and improving irrigation practices. While in the humid areas any wide change in the existing cropping pattern and agricultural practices may not arise, these will have to differ greatly in the case of arid tract, if one is to achieve the most efficient utilisation of limited water sources with the minimum construction cost of canals and distribution systems. It is, therefore, important to determine in advance more about the amount of water required by crops so that maximum production can be obtained and a well plannd cropping pattern can be formed.

Water Requirement

Scientifically " Water Requirement " is defined as the ratio of the weight of water absorbed by a plant during its total period of growth to the weight of dry matter (exclusive of roots) produced during the same period. This is generally determined by pot culture method under controlled conditions without any losses by percolation and surface evaporation. For farmers, however, the water requirement includes water used by plants in transpiration and for production of tissue, water lost by evaporation from the soil, and water normally lost during irrigation due to seepage through water channels and distributaries and as a result of inefficiencies in the application of water in the fields. In determining the total water requirement under field conditions the following items are thus to be considered: (1) Evotranspiration or consumptive use and (2) irrigation losses including run off and percolation. Heavy losses have been observed due to evaporation from the storage tanks and percolation through the canals and distributaries even before the water reaches the field. In the Deccan Canal tract these losses are estimated to be over 40 per cent of the total water stored in the catchment.

The water application efficiency on any given farm is often very low. Isralsen found that efficiencies as low as 20 per cent are very common and that for a relatively large area the average efficiency may not exceed 30 to 40 per cent. Perhaps the greatest single factor influencing the water needs of the a farm is the soil. Although in theory the water needs of a crop grown on light sandy soils should be no greater than if it were grown on a heavy clay, the waste is usually larger because of high infiltration rates and thus the irrigation efficiencies are often very low. Further, owing to the low storage capacity of this soil more frequent irrigations are required, which combined with the lower efficiency may result in excessive water use in a given field. These efficiencies can be, however, improved greatly by the adoption of proper methods of irrigation suited to different soil types, their topography and the crops to be grown. Furrow, sub-irrigation and sprinkler irrigation are more efficient in this respect.

Several methods are used in determining when to irrigate any crop and the amount of water to be applied. Most of these, however, give more importance to the control of the irrigation interval than to controlling irrigation efficiency or the amount of water delivered in the fields. Some of the most important methods include growth measurements, soil moisture determinations, day degrees of temperature, tensiometers, nylon blocks and evaporation data. It is generally accepted that for the crops with well developed root system permeating the crop root zone the use of water should not be influenced by moisture level in the soil so long as it is above the permanent wilting point. It would be thus evident that, if the amount of readily available moisture that can be stored in the crop root zone and the rate at which crop is using water are known, then over-irrigation and waste of water in many cases can be materially reduced. The objective approach to determine the amount of water to irrigate a crop thus involves the following steps: (1) estimation of the water required to fill a foot depth of soil to capacity, (2) estimation of the crop root zone, (3) estimation of soil permeability or the rate at which water will enter the soil from surface application of irrigation water, (4) calculation of the time the head of water available should be applied to a given area of the soil

of a known permeability to provide the required quantity of water and (5) adoption of proper method of irrigation suited to the soil type and topography.

A great deal of work on the above lines has been done at Padegaon in the Bombay State and at Risalwala in the old Punjab. Sufficient information is thus available on the evotranspiration or the consumptive use of water which can be obtained from the annual reports and published papers. These results can thus form a good background for framing cropping patterns for the new projects based on the meteorological conditions of these areas. In United States several formulae have been developed for the transfer of consumptive use data from one area to another. It has been found that as irrigational requirements at comparable stages of growth are related to evaporation from free water surface, this fact forms the most practical means of transferring irrigational requirements and consumptive use data from one area to another. According to Musgrave (1950) the relationship " F " between the water lost from a given cropped area and water evaporated from an equal free water surface using standard open pans comes to 0·60 on an average. If, however, for any area data of evaporation from free water surface are not available, other climatic data can be used for determining evotranspiration potential. Blaney and Griddle (1950) have in their formula taken into account the mean monthly temperature and monthly per cent of annual daytime hours. Penman (1948, 1951) has based maximum evaporation on an energy balance concept. His calculations involve the use of the following (1) total monthly radiation estimated from hours of bright sunshine, (2) mean monthly air temperature, (3) mean monthly dew point temperature and (4) mean wind speed. Based on Penman's method the Meteorological Service in England issues an estimate for maximum evaporation from crop land as a guide to irrigation. It is felt that the Agricultural Meteorological Section in Poona, can usefully take up this work, in view of the large area which would be coming under irrigation with the new vast irrigation projects. This will obviate the necessity of conducting basic experimental work on water requirements of crops for each of the areas.

There are, however, certain factors which are likely to mask the transfer of the evotranspiration ratios fully to other areas based on climatic factors alone. Among these the presence of water table is of primary importance. The water table can be of sufficient height to prevent optimum growth or it can be low enough not to interfere with aeration and at the same time of just sufficient height to provide water for deep rooted plants. The experimental work at Padegaon has shown that the presence of water at a depth of 4½ ft. has been beneficial both from the standpoint of increase in yield by 20·6 per cent and reduction in water requirement by 34·0 per cent in the case of sugarcane crop. Another factor of importance is the ability of crops to withstand soil moisture stress. The relations of irrigation requirement to meteorological conditions described above have been worked out on an actively growing or turgid crop and these will naturally be affected in case of arbitrary irrigation intervals as often adopted in the irrigation management in India resulting in moisture stress in soil. In the Deccan Canal Tract of Bombay State fluctuating irrigational intervals which are followed by the Irrigation Dept., more for the convenience of the canal management create such moisture stress conditions in the sugarcane crop specially during the summer months, seriously affecting the growth of the crop. In the canal irrigated areas of Madras and Andhra States the system of closure of the canals annually for a period of a month or more during summer has been also highly deleterious to cane both from the standpoint of growth and increase of borer and other pests. It would be thus evident that under such conditions the relationship with meteorological factors would be hardly as close as obtained theoretically.

Cropping Patterns

In fitting a cropping system to any irrigation project it is not only necessary to know the water requirement of each crop, but also the actual demands at various periods during the season. The general sequence of peak demand as well as the comparative duration of water need would be similar for various regions, although the actual water requirement and seasonal dates may fluctuate considerably. It would be thus necessary to determine the water requirement of various crops per each month and to utilise such information for framing cropping patterns with a view to obtain maximum crop production with limited water supplies. Earlier in summer the crop matures the less water it needs. Accordingly the adjustment of the seasonal crops to long term crops should be such that the latter, who grow throughout the period of maximum transpiration and thus tend to have heavy water demands should not suffer in their irrigational requirement at any time of the year. At the same time a proper proportion of such long term crops as sugarcane, banana and fruit trees should have to be maintained in order to utilise the water to the best advantage during summer months when hardly any seasonal crops are grown.

Problems to be Faced in Irrigation Management

As a result of detailed experimental work at Padegaon in the Bombay State and Risalwala in the old Punjab State sufficient information is now available on the water requirement of important crops. It has

been further shown that the data of irrigation requirements of consumptive use of water as obtained at these centres can be transferred to other areas by utilising either the data for evaporation from free water surface or other climatic data as available for these areas. There would be thus no need to undertake such detailed research work for each region to be brought under irrigation in order to determine evotranspiration for different crops.

In order to achieve efficient irrigation management, however, the following problems require careful consideration:—

(1) In any irrigation project the question arises as to whether the water resources should be used for intensive cultivation of crops with optimum quantities of fertilisers and water with a view to secure maximum production per acre thus restricting the total irrigated area or to spread the water on as wide a cropped area as possible to secure normal yields. In the present context of the collection of irrigation dues on acre basis, the latter method may bring in a higher revenue but it would be evident that it would lead to wastage of water by percolation during the transit of water on such wide areas, and this may be very high in light soils. In the case of intensive cultivation high moisture range will have to be maintained with a view to get the maximum advantage of fertilisers applied to the soil. Although no one percentage of moisture above the permanent wilting can be considered as optimum for plant growth there is sufficient experimental evidence to show that the growth rate of various plants decreases markedly in the available soil moisture range and that vegetative growth is completely inhibited by the time the soil moisture is depleted to the permanent wilting range. Under field conditions maintenance of high moisture level in the soil throughout the growth period would, however, lead to low water application efficiency resulting in greater use of water than the evotranspiration potential. The effective check against wastage of water would be, however, the adoption of the system of selling water by volume which should then make up for any fall in the irrigational dues. Further such intensive cultivation would encourage the adoption of efficient methods of cultivation and manuring avoiding losses in transit on wide areas.

(2) There is a great wastage of water during transit in the canals and distributaries, which can be effectively used for irrigation by proper lining of the distribution system. While as a result of the experimental work at Padegaon the irrigation requirement of sugarcane was found to be 95″ inclusive of rainfall of about 19″ during the period of 12 months, even 124″ exclusive of rainfall at the distributary head allowed by the Irrigation Department, is not considered adequate by the cane plantations in the Deccan Canal tract. Large scale trials on the plantation estates have also confirmed 95″ to be the optimum field irrigation requirement. It is thus evident that the inadequacy of 124″ at the distributary head would be mainly due to transit losses. It is estimated that on an average atleast 25 per cent of the water flowing through the canal is lost by seepage and percolation in the Deccan canal area before it reaches the cropped field. In the arid tract, once the advantage of irrigation is realised by the cultivators, there would be a great demand for irrigation which, as in the case of the Deccan canal tract, would exceed the supply mainly due to such high losses in transit of water to the fields. Lining of the canals would thus not only save all this water for crops but in addition reduce the chances of water logging and salt efflorescence, as well, as observed on the developed canals.

(3) In India the Irrigation Department is fully in charge of the irrigation management. It would be obvious that while this department would be competent to look after the construction and up-keep of canals and distributaries, it is not normally expected to be so well versed in the science of irrigation requirements of crops. The result often has been the adoption of arbitrary methods of distribution of water not closely related to the irrigation requirement of crops. It is the Agricultural Department who should thus have a prominent say in framing cropping patterns and in the distribution of water according to irrigation requirements of crops. All experimental work leading to the knowledge of the amount of water consumed in growing each crop and the efficiency with which it can be applied loses all its significance and value if the results so obtained cannot be properly utilised in the irrigation management.

REFERENCES

Blaney, H. F. and Griddle, W. D. (1950). W. S. D. A. Soil Conservation Service.
Musgrave, G. D. (1950). *Ibid.*
Penman, H. L. (1948). *Proc. Roy Soc.* (London), A. 193.
——— (1951). *Quart. J. Roy. Meteorol Soc.*, 74.
Rege, R. D. and Basu, J. K. (1948). Sugarcane Res. in the Bombay Deccan, 1932-1944.

ONE-EYE-BUD VERTICAL-AN EVOLUTION IN THE METHOD OF PLANTING SUGARCANE

By

Y. R. Joglekar and J. V. Limaye

Introduction

IN the Deccan as elsewhere in India Sugarcane is cultivated as a crop for the last two-thousand years at least. For years together it was planted in flat beds. But when new varieties were introduced the technique of planting changed. It is now grown in ridges and furrows. As sugar factories were established and large scale planting was started mechanical cultivation also came in gradually. To suit the tractor working the breadth of the furrows changed from two feet to anything like five feet.

But during all this period the material planted per acre never changed. No change in the number of buds to a sett or in its position at planting took place. In Walchandnagar breadth of the furrow was increased to 5′ for Mechanical cultivation. As the furrow breadth increased the crop seemed to close-in late. In such a crop even small gaps appeared to be quite big. To fill-in these gaps seedlings from One-Eye-Bud cuttings were planted. This gave rise to the idea of a new method of One-Eye-Bud Vertical planting in Sugarcane.

Method of (One Eye Bud Vertical Planting)

Preparatory Tillage

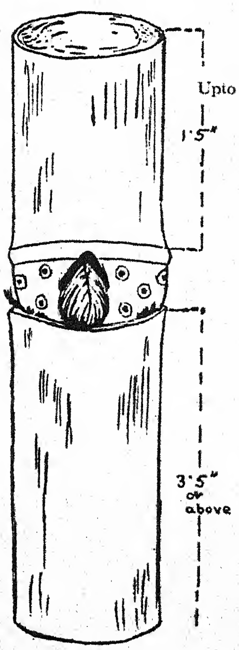
This is the same as in the normal planting.

Treatment to seed-plot

Fifty pounds of Nitrogen per acre is given, in irrigation water, in inorganic form, one month prior to cutting the plot for seed-material. This treatment improves the germinability of the seed.

Cutting of seed setts for planting

The sett is cut as shown in the diagram. The sett is cut up to 1·5″ above the bud so that the bud should go that much deep in the soil only when it is pressed in it. If this part of sett above the bud is kept more than 1·5″, the sett may dry up due to exposure to sun and air. The length of the sett below the bud does not matter as it is to go in the soil only.



Seed-rate

Eight thousand One-Eye-Bud setts per acre.

Planting

Wet planting is easier. Setts are spread over the ridges at a distance of 1·5′ before irrigation. Plots are irrigated and when water gets soaked in the soil they are pressed in it vertically. Short end of the sett i.e. the end of the sett above the bud is held in the hand at the time of planting, so that the setts are planted in the soil in the desired position.

Rest of the cultivation is the same as in normal planting. Manures are applied just near the clumps for various doses.

If the germination is to the extent of 70-75 per cent (more than 5,500 clumps per acre) only those gaps which are more than 3′ wide are required to be filled in.

Literature Review

We have come across a few references when we reviewed literature to see if any work has been done on these lines. References are as under:

(i) Mr. Jayaram of Nellikuppum tried one-eye-bud rayungans and not one-eye but setts. " Secnod biennial conference of Sugarcane research and development workers of India (1954). "

(ii) Dr. A. K. Dutt of D.V.C. tried one-eye -bud planting—as stated in Soil and Water Conservation in India, Vol. 1 (3) (April 1953).

(iii) Mr. Lakshmi Kantham tried one-eye-bud rayungans for rapid multiplication of sugarcane seed material " The Andhra Agricultural Journal, Vol. III (3), 1956. "

Experimental Data

On the strength of the various trials since 1952, a large scale experiment was laid out in 1957-59 season in Adsali No. 26.

(i) Layout:—A BB A Pattern.

(ii) Treatments:—A.—O.E.B. Vertical planting 8,000 O.E.B. setts per acre.
B.—Normal planting. 12,000 three-buded setts per acre.

(iii) Ridges and furrows:—3·5′ apart.

(iv) Plot size:—10 gts. each.

(v) Manures:—

	Nitrogen	Phosphoric acid	Potash
	N_2	P_2O_5	K_2O
Per Acre	500 lbs.	75 lbs.	100 lbs.

(vi) Replications:—Four in one block.

(vii) No. of blocks:—One each at Ratnapuri, Lalpuri and Veerpuri.

No gap filling was done at any one of the sections in any one of the treatments. Germination in O.E.B. Vertical has been the poorest at Lalpuri. It is worthwhile to note that this plot at Lalpuri has given more sugar than the control.

Discussions

Why reduction in seed rate ? With reduction in seed rate cane produced is heavier and of a better quality giving atleast same yield as in normal method and more sugar per acre. Hence use of large quantity of seed material is a national waste. (Table I).

Why one-eye-bud vertical and not Horizontal?

In an experiment with seed rates of 6,000; 7,000 and 8,000 one-eye-bud setts planted vertically and horizontally it was observed as in Table II.

Number of canes in Horizontal planting is slightly more . But per cane weight in the same is less. Actual weights per 1 gt. plot in Horizontal and vertical planting confirm the findings.

TABLE I

Observations and results of harvesting

Section of Expt.	Ratnapuri		Lalpuri		Veerpuri	
	A	B	A	B	A	B
Date of planting	24-8-1957	24-8-1957	14-8-1957	14-8-1957	16-8-1957	16-8-1957
Germination percentage in 1st. Month ..	67	67	36.60	68·80	55	55
Cane count in April, 1958	47,000	60,000	47,000	71,000	47,000	80,000
No. of millable canes at harvest	33,000	36,000	36,000	36,000	30,000	35,000
Average No. of clumps/stools in 33' ..	12·50	17·20	8·50	19·00	12·80	18·70
Average No. of canes in clump/stool ..	9·00	7·50	12·30	7·50	12·00	6·70
Average No. of canes per ft. length ..	2·70	2·80	3·30	3·00	2·80	3·00
Average weight of a cane in a clump/stool ..	4·00	4·50	5·50	5·00	4·50	4·10
Average No. of nodes in a cane	37·00	37·50	35·00	38·00	33·00	38·00
Average Brix of canes in a clump/stool ..	21·30	19·70	21·10	21·40	22·30	20·90
Yield in tons P/A.	56·75	53·00	72·15	78·54	54·15	53·95
Sugar percentage	12·49	11·69	12·67	11·14	13·27	12·69
Sugar tons P/A.	7·09	6·20	9·14	8·95	7·18	6·88

TABLE II

Cane Counts			Average weights of 1 gt. plot		
Seed rate	Canes in 66' Planted length		Seed rate	Average yield in tons in 1 gt. plot	
	Vertical	Horizontal		Vertical	Horizontal
6000	207	216	6000	0·90	·97
7000	186	181	7000	1·45	1·42
8000	177	244	8000	1·93	1·64

TABLE III

Labour required for planting

	Ratnapuri		Veerpuri	
Method of planting	Men	Women	Men	Women
O.E.B. Vertical Planting ..	4	..	2	2
Normal Planting ..	6	..	2	3

Is more labour required for planting?

It is clear from the above table that labour required for vertical planting is not more than is required for normal planting.

SUMMARY

(i) When One-Eye-Bud setts are used, there is a great saving in seed-material.

(ii) One-Eye-Bud vertical planting improves the quality of cane and

(iii) Gives more sugar per acre.
(iv) There is saving on transport.
(v) This method is as easy as the normal method of planting cane and does not require more labour.
(vi) Finally there is reduction in the cost of per bag of sugar produced.

ACKNOWLEDGMENT

We are very thankful to the management of Messrs. Walchandnagar Industries Ltd., and to the Farm Manager for giving necessary facilities to us to carry out this work.

LEAF NITROGEN STUDIES UNDER DIFFERENT MANURIAL AND CULTURAL PRACTICES IN SUGARCANE

By

S. C. Varma* and H. P. Verma

(Sugarcane Research Station, Shahjahanpur, Uttar Pradesh)

Introduction

In assessing the performance of the new cane varieties, stress has been laid on differences in their morphological characters, their reaction to various cultural and manurial practices and finally on the overall production of millable cane and recovery of commercial sugar. It is evident that sugarcane varieties differ in their physiological behaviour resulting in differential performance under similar fertility levels of the soil. The chemical composition of the varieties reflects to a great degree the physiological capacity of these varieties to absorb and assimiliate the various nutrients available in the soil under a particular set of climatic conditions.

Recent investigations in Hawaii on sugarcane have been directed towards the search of an index of elements of nutritional importance; Clements (1940), Clements and Kubota (1943) suggested that for sugarcane, the sugar content of young leaf-sheath would provide such an index. Clements and Moriguchi (1942) used leaf blades of sugarcane for nitrogen determination and young sheath for estimation of potassium and phosphorus status of plants. Borden (1942) and (1944) too used the technique of plant analysis for the determination of nitrogen requirement of sugarcane.

Insufficient efforts seems to have been made so far to corelate the yield of cane with the variation of nitrogen content of the sugarcane plant as indicated in its leaf under different manurial and cultural conditions. Mohan Rao and Narsimham (1956) have however found that leaf nitrogen in early growth period was highly corelated with cane yield under optimum or sub-optimum conditions of nutrition. As nitrogen is one of the essential constituent of the plant cells, the plant growth is closely related to its intake, and it is considered that such a study may prove to be both useful and informative. The investigation reported in this communication gives an inter-relation between cultural and manurial conditions and the chemical composition of the plant so far as nitrogen is concerned.

Material and Methods

The experiments described here were carried out for a number of years and in all cases total nitrogen which includes both colloidal and non-colloidal nitrogen was determined in the first fully emerged leaves. Micro determination of nitrogen was carried out by the usual method as recommended by Pregle and Pregle (1945). The total nitrogen was determined after reducing the nitrates in the presence of reduced iron.

The fertiliser was evenly spread by hand on either side of the rows according to experimental requirements and was followed by an irrigation. For each irrigation the plots were flooded with canal water till three inches of water stood on field surface.

Method of sampling

Leaf samples consisting of first fully emerged leaves from three different plants of each row of a plot excluding the border rows were collected and were immediately brought to the laboratory cut into suitable sizes and put in an electric oven having a temperature of 95° to 100° for drying. This dried material was stored and used for subsequent analysis.

Results

Variation of nitrogen in leaf under different levels of nitrogen doses applied to the field

Table I shows the nitrogen content in leaf (averages of three years) under different doses of nitrogen applied as fertilizers (Ammonium sulphate). It will be seen that at the start nitrogen content in the leaf under all the three levels of application is almost the same. But with 125 lbs. nitrogen treatment it increases slightly and then declines gradually till the end still it is higher than at the other two levels. At 75 lbs. level, however, it drops rapidly upto August after which the fall is gradual. At no nitrogen level the fall in nitrogen content of the leaf on the other hand is very rapid upto August after which it is gradual.

*Now Principal, A. S. Jat College, Lakhaoti (Buland Sahr, U. P.

TABLE I

Total nitrogen per cent dry weight in leaf under different Nitrogen levels (average of three years)

	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.
No. Nitrogen	1·653	1·415	1·171	1·075	1·050	1·031	0·969	0·915	0·889	0·980
75 lbs. Nitrogen	1·711	1·636	1·576	1·385	1·387	1·229	1·198	1·035	0·982	0·897
125 lbs. Nitrogen	1·681	1·721	1·639	1·593	1·506	1·361	1·228	1·095	1·041	1·046

When 125 lbs. nitrogen figures are compared with others a very interesting fact emerges out. During the earlier period when the absorption of nitrogen seems to be highest in the plant, nitrogen in the leaf is maintained at a high level in the higher doses for a longer period in the no nitrogen treatment the fall starts from the beginning.

Variation of nitrogen in leaf under normal and deficient irrigation

In normal irrigation treatment, five to six irrigations were given. One of these was given during April, two were given in May and two were given in June, and under deficient irrigation treatment only two irrigations were given. Natural precipitations were received by both equally.

Table II contains results of two years—one covering the period upto the rainy season and the other upto the harvest time. From the table it will be seen that the differences in nitrogen in the leaf are shown only before the commencement of the rainy season. Nitrogen is higher in the normal than under deficient irrigation upto the middle of June but when the rains set in (usually after 15th June in these parts) nitrogen absorption seems to suddenly shoot up under deficient irrigation. In August and September there is again more nitrogen in the normal than under deficient irrigation. At the end of the rainy season (Mid. October) deficient irrigation, seems to have reacted very favourably to natural irrigation.

TABLE II

Total nitrogen per cent in leaf (dry weight basis) under normal and deficient irrigations

A	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.
Normal irrigation	1·606	1·562	1·469	1.439	1·308	1·988	0·845	0·805	1·057
Deficient Irrigation	1·392	1.628	1·388	1·365	1·323	1·022	0·909	0·700	0·887

B	May 15	June 1	June 15	July 1
Normal Irrigation	1·562	1·656	1·503	1·315
Deficient Irrigation	1·456	1·554	1·484	1·366

This indicates that water is a limiting factor for nitrogen uptake till the rains begin and it is, therefore, essential to irrigate during the dry period for better utilisation of the fertiliser applied.

Variation of nitrogen in the leaf under piecemeal and single dose application of nitrogenous fertiliser

Table III shows total nitrogen per cent in the leaf when 100 lbs. nitrogen as ammonium sulphate has been applied in one dose with the first irrigation near the sowing time and also when it is applied in fractions (50 lbs. at sowing time and four fractions of 12·5 lbs. each at intervals of about a month). It will be seen that nitrogen per cent stands high when the fertilizer is applied in a single dose than when it is given in piecemeal doses. In the Table the figures for no nitrogen treatment are given for the sake of comparison. The figures for both the single and piecemeal doses, application are much higher than no nitrogen. It will be noted that with no nitrogen the falling tendency is observed from the start but the application of manure either in single or piecemeal doses checks this tendency till July after which this fall is gradual in all cases. It indicates that the application of fertiliser in the beginning serves to keep the nitrogen status of the plant at a higher level and if the application is in single dose the plant continues to keep up this status till the end. From the piecemeal

application results it appears that the method of application of fertilizer, when it is found deficient in the plant is not at all sound in practice, because it appears that the plant does not stand a sudden shock and resists picking up nitrogen when applied in doses but appears naturally to be adjusted to the gradually taking up of its food from a single large dose application which may have adjusted to this biological balance in the field during its long and continuous stay. These observations thus run counter to the tendency to apply manure in piecemeal doses. The results noted here agree with the observations of other workers. Borden (1945) in Hawaii found that the best quality of cane was obtained when the total nitrogen had all been applied by the 4th month and poorest when given in piecemeal at later dates.

Mohan Rao and Lakshmi Kantham have observed similar trends in Andhra.

TABLE III

Total nitrogen per cent in leaf (dry weight basis) under piecemeal and single dose application of 100 lbs. of nitrogen as ammonium sulphate

Treatments	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.
100 lbs. nitrogen in single dose ..	1·657	1·576	1·624	1·443	1·383	1·238	1·090	1·004	0·951
100 lbs. nitrogen in piecemeal doses	1·503	1·578	1·551	1·390	1·289	1·169	1·066	1·035	0·964
No nitrogen ..	1·653	1·415	1·171	1·075	1·050	1·031	0·969	0·915	0·889

Variation of Nitrogen in leaf due to different time of application of manure

Table IV shows the total Nitrogen in leaf at monthly intervals in treatments where 100 lbs. nitrogen as ammonium sulphate has been applied near the sowing time or else in May during the tillering phase.

TABLE IV

Total nitrogen per cent in leaf (dry weight basis) under application of fertiliser at sowing time and at tillering time

Treatments	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.
100 lbs. nitrogen at— A. Sowing time	1·933	1·905	1·688	1·217	1·350	0·946	0·925	1·028	0·853
B. Tillering time	1·787	1·716	1·671	1·262	1·227	0·896	1·022	1·015	0·775

In general it may be stated that the nitrogen in the leaf under sowing time remains mostly at a higher level than under tillering time. As stated before, the plant is better suited to utilise the fertiliser when applied in the early stages than when applied later. Nitrogen status in the leaf thus supports the observation that it is advantageous to apply the fertilizer at the sowing time. From Tables III and IV it appears that it is adavntageous to apply the fertilizer in a single dose near the sowing time.

Variation of nitrogen in leaf with the application of different nitrogenous manures

Table V gives the total nitrogen in the leaf when 100 lbs. nitrogen per acre is applied in different forms. It will be seen that in all the cases ammonium sulphate gave the best performance i.e. the nitrogen in the leaf remained higher than in other cases. The figures for ground-nut cake were very near those for ammonium sulphate. They rise till August and then show a fall upto November, after which there is a gradual rise in the figures till the end. Figures for castor cake also show a rise upto August. Figures for both farm yard manure and municipal compost show an increase till September (August in the case of ammonium sulphate) then a fall till November and a gradual rise till the end. Contrasting the behaviour of organic and inorganic manure it will be seen that nitrogen in leaf begins to fall from August in ammonium sulphate but with farm yard manure and Municipal compost, it remains high till September. The nitrogen availability of ground-nut cake is better than other organic manures under test and compares favourably with that of ammonium sulphate. It may be noted that nitrogen per cent in leaves shows a tendency to increase after December under

all the treatments. This does not appear to be due to increased availability of nitrogen in the soil, but perhaps related to an increase in growth activity in the case of the variety (Co. 421) under test.

TABLE V

Total nitrogen per cent on dry weight of leaf of Co. 421 *with the application of different types of nitrogenous manures*

Treatments	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.
Ammonium Sulphate	1·530	1·574	1·798	1·624	1·590	1·123	0·901	1·215	1·104
Castor Cake ..	1·479	1·519	1·597	1·553	1·592	1·048	0·989	0·962	1·057
Ground-nut Cake	1·500	1·578	1·749	1·562	1·513	0·897	0·964	1·053	1·060
Farmyard Manure	1·487	1·305	1·413	1·493	1·385	0·960	0·922	1·028	0·979
Control (No. Additional Nitrogen) ..	1·490	1·599	1·402	1·344	1·319	0·951	0·944	0·945	0·982
Municipal Compost	1·535	1·485	1·529	1·591	1·242	0·945	0·894	0·914	0·874

Variation of nitrogen in the leaf in different varieties

For this experiment six popular varieties viz. Co. 421, Co. 527, Co. 453, Co. 313, Co. 331 and Co. 557 were taken and their leaves analysed as before. Table VI gives the data for nitrogen in leaves of different varieties grown under similar nitrogen (100 lbs. Nitrogen as ammonium sulphate) and irrigation levels. It will be seen that Nitrogen rises in all varieties in the beginning but begins to fall from July onwards except in Co. 421. In Co. 421 the fall begins a month later. In the earlier period the nitrogen is higher in Co. 321, Co. 557 and Co. 527 than in the rest. In Co. 527, however, it remains high till January.

TABLE VI

Total nitrogen per cent in leaf (dry weight basis) in different varieties

Varieties	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Yield per acre (Mds.)
Co. 313 ..	1·606	1·562	1·469	1·439	1·308	0·988	0·845	0·805	0·800	487
Co. 421 ..	1·647	1·762	1·789	1·548	1·317	0·977	0·877	0·882	0·951	734
Co. 331 ..	1·613	1·679	1·508	1·324	1·340	1·067	1·020	1·035	1·004	816
Co. 557 ..	1·732	1·763	1·725	1·594	1·438	1·196	1·044	0·929	0·922	698
Co. 453 ..	1·560	1·793	1·578	1·369	1·266	1·056	1·031	0·946	0·950	855
Co. 527 ..	1·647	1·774	1·652	1·528	1·446	1·251	1·251	1·050	0·977	785

From the yield data given in the last column of Table VI it will be seen that the high yielding varieties do not necessarily have high nitrogen in leaf. Nitrogen status, thus like vigour, seems to be a hereditary characteristic of a variety.

SUMMARY

The following inter-relations seem to be indicated between nitrogen in the leaf and the various cultural and manurial practices:—

1. Application of higher nitrogen doses are reflected in the high nitrogen content of the leaf and the corresponding higher uptake of nitrogen by the whole plant.
2. Nitrogen in the leaf is higher in the irrigated plots than in the non-irrigated plots only during the dry period. After the onset of monsoon the differences disappear.

3. Nitrogen in the leaf is always higher when nitrogenous fertilizer is given in a single dose than when applied in fractions (piecemeal doses).
4. Nitrogen in the leaf mostly remains higher when fertilizer is applied at sowing time than when it is applied at the tillering time.
5. Nitrogen in leaf is high when the nitrogen is applied in the inorganic form.
6. The nitrogen levels of leaves of the varieties tested do not seem to bear any relation with their yields.

Acknowledgment

The authors' thanks are due to Dr. B. K. Mukerji, the former Director of the Station for his guidance during the progress of the present work. They are also indebted to Dr. J. G. Shrikhande, Director, Sugarcane Research for his valuable advice and suggestions. They are also indebted to the Indian Central Sugarcane Committee for partly financing the scheme of work.

REFERENCES

Borden, R. J. (1945). The effect of nitrogen fertilisation upon the yield and composition of Sugarcane. *Hawaii Plant. Rec.*, **49**: 259.

——— (1942). A search for guidance in the nitrogen fertilisation of the Sugarcane crop. Part I. The plant crop. *Hawaii Plant. Rec.*, **46**: 191-238.

——— (1944). A search for guidance in the nitrogen fertilisation of sugarcane crop. Part II. The first ratoon crop. *Hawaii Plant Rec.*, **48**: 271-306.

Clements, H. F. (1940). Integeration of climatic and physiological factors with reference to the production of Sugarcane. *Hawaii Plant Rec.*, **44**: 201-33.

Clements, H. F. and Kubota, T. (1943). Internal moisture relation of Sugarcane. The selection of a moisture Index. *Hawaii Plant Rec.*, **46**: 17-36.

——— and Moriguchi, S. (1942). Nitrogen and Sugarcane. The Nitrogen index and certain quantitative field aspects. *Hawaii Plant Rec.*, **45**: 227-39.

Mohan Rao, N. V. and Narasimham, R. N. (1956). Some aspects of Nitrogen Nutrition of Sugarcane in Ahdhra. *Proc. IX to P.S.S.C.I.*: 74-91.

Pregl, F. (1949). Quantitative organic micro-analysis.

YIELD POTENTIALITIES OF SUGARCANE AND ITS MAXIMISATION IN MADRAS STATE WITH SPECIAL REFERENCE TO SOUTH ARCOT DISTRICT

By

S. VAITHINATHAN

(Sugarcane Research Station, Cuddalore, Madras)

INTRODUCTION

THE consumption of sugar in India has increased considerably during the recent years. Steps have, therefore, been taken by the Government of India to meet this increased demand for sugar, by establishing more sugar factories, and also by raising the capacities of the existing ones. Though these steps are bound to increase the production of Sugar the agricultural aspect also plays an equally vital role in increasing the production of sugarcane which is the basic raw material for the sugar industry. It is, therefore, proposed to discuss in this paper the place of agriculture in the sugar industry and how cane cultivation and sugar production in Madras State have developed during the past ten years.

The two factors that go hand in hand in the maximisation of sugar production, are the yield of cane per unit area and the quality of the cane i.e. the extent of sugar available in the cane stalks. These two factors are combined and called in recent years as "*sugar per acre*". The maximisation of sugar per acre, therefore, lies in the hands of the cultivator of this raw material.

Low cane yield has always been the bane of the sugar industry in this country. The industry had been frequently complaining of shortage of cane supplied to the sugar factories from growers to keep the factories working even to the minimum period of 120 days in the north and 200 days in the south. Hence, if all the factories should be able to crush to their full capacities at least for 150 days in a year and all the new sugar factories proposed to be established in the future are also to be supplied with cane to their maximum capacity, it is essential that the yield of sugarcane has to be increased to a considerable extent. Increasing the area under sugarcane could solve this problem to some extent, but other conflicting factors come in to the picture. Hence the easier and rational method would be "*Maximisation of the acre yield of cane*". While attempting at this method, care has to be bestowed to produce cane of good quality, as canes of low quality i.e. of lesser sucrose content, yield less of sugar.

CANE YIELDS IN MADRAS STATE

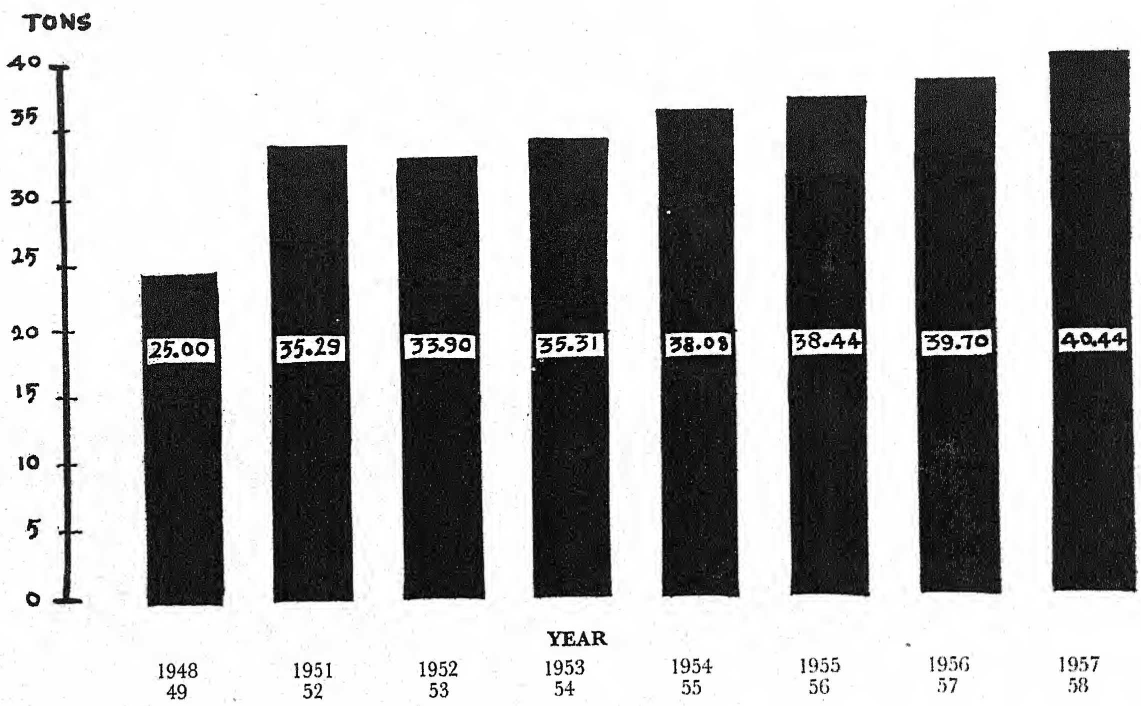
The official statistics go to show that the average yield of cane in India is about 14 to 15 tons per acre only. These yield figures are so low as compared to high average yields of 62 tons in Hawaii and 56 tons in Java. Though the All-India average yield of cane appears so low, some of the States like Bombay and Madras have been recording high yields of cane as shown below:—

Bombay— 40·72 Tons (18 months crop).
Madras— 38·29 tons (12 months crop).

In the Madras State the sugarcane Development Scheme was initiated in the year 1949-50. The average yield of sugarcane in this State during 1948-49 were 25·70 tons per acre though yields of 40 to 60 tons per acre were being harvested by individual ryots. A target of 36·5 tons of cane per acre was aimed at by the end of the first Five Year Plan period i.e. 1955-56 in the cane Development areas. But this target was achieved and even exceeded by the end of 1954-55 itself with 38·87 tons per acre and by the end of the first Five Year Plan period in 1955-56, yield of 39·70 tons of cane per acre was achieved. The average yield of cane rose upto 40·04 tons per acre during 1957-58 season. Though this is an average estimated yield, yields of cane from 40 to 80 tons are very common with the cane growers of this State. Over 100 tons of cane per acre have been obtained by the cane growers consistently from the year 1951-52 onwards i.e. the year during which the sugarcane crop yield competitions scheme was introduced as shown below:—

Year		Competitions	
		Tons	lbs.
1951-52	..	96	140
1952-53	..	103	1580
1953-54	..	94	1840
1954-55	..	129	03
1955-56	..	115	60
1956-57	..	143	153

The above facts go to show the potentialities of obtaining very high yields of cane in this State.



GRAPH C.

Yield of cane in Tons per acre (Madras State) development zones.

SUGARCANE IN SOUTH ARCOT DISTRICT

Nearly one-fifth of the total area under cane in Madras State, is grown in the South Arcot District alone. This district has the privilege of having one of the biggest sugar factories in the South with a crushing capacity of 2,200 tons per day (The East India Distilleries and Sugar Factories Limited at Nellikuppam), and nearly 2/3 of the total production of white sugar in Madras State is produced from this factory alone.

The cane cultivation in this district has always been of a high standard and the cultivation has been mostly in the hands of progressive and enthusiastic ryots. After the introduction of the sugarcane development scheme in 1949-50, the cane growers of this district were helped to improve their cane cultivation still further, by adopting the improved scientific methods of cane cultivation as recommended by the sugarcane section of the State Agricultural Department. This achievement is well depicted in the high cane yields obtained by the ryots of this district in the sugarcane crop yield competitions as shown below (Table I):

TABLE I

Year	Highest yields of cane obtained	Average yield of cane in the District
	Tons-Lbs.	
1951–52	87– 448	27·47
1952–53	99– 753	29·54
1953–54	85–2509	28·54
1954–55	129– 3	26·33
1955–56	115– 60	36·49
1956–57	143– 153	38·44

Factors Responsible for High Cane Yields in South Arcot District

It is seen from the data shown above how Madras State and South Arcot district in particular, have potentialities for producing high cane yields. Sugarcane is a crop which requires plentiful supply of water and fertilisers for its growth. The cane cultivation in South Arcot district is mostly under gardenland conditions, under lift irrigation, and this aspect greatly helps in the judicious control over irrigation and the economic use of fertilisers.

The next in importance to water and fertilisers is the selection of high-yielding varieties of cane. Dependence on a single variety is neither safe nor economic. The cane cultivators of this district have fully understood this important aspect and are, therefore, growing high-yielding cane varieties and are also adopting a system of varietal schedule, with cane varieties suitable for early, mid and late season crushings. They have readily taken up to the selection of varieties as and when necessary as this item of improvement does not involve any additional expenditure. To this extent, the sugar factory authorities at Nellikuppam, in collaboration with the Agricultural Department, have played a vital role in infusing the idea for change of varieties among the cane growers, as and when found necessary to do so.

Sugar Factory at Nellikuppam

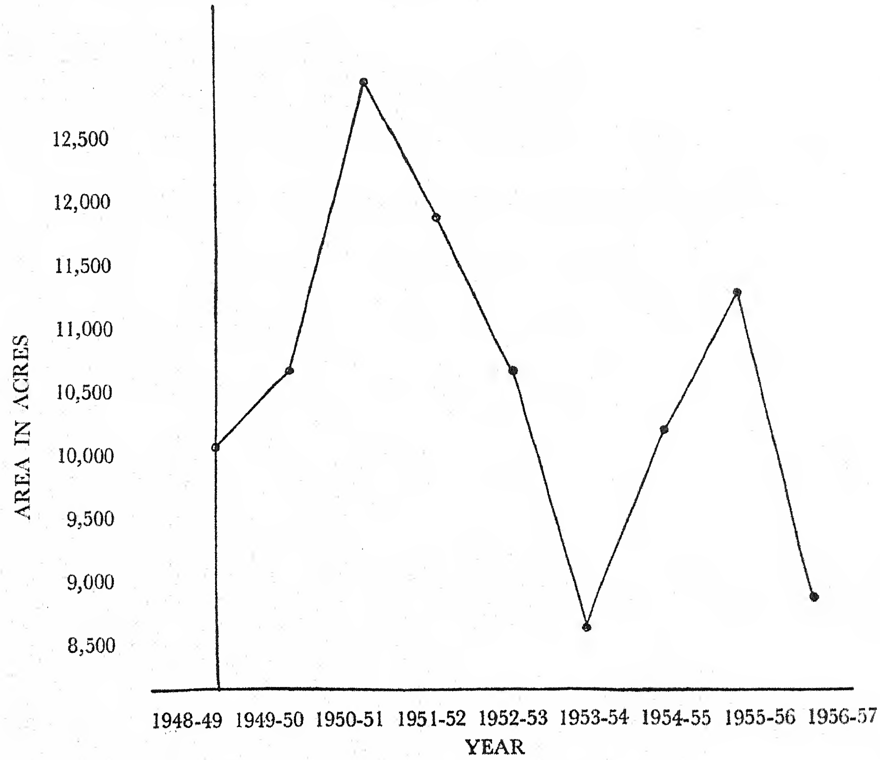
Out of the total area of about 28,000 acres under sugarcane in this district, about 10 to 12 thousand acres are utilised for the production of sugar by the East India Distilleries and Sugar Factory Limited at Nellikuppam. How the adoption of varietal schedule by the selection of high yielding varieties of cane and better standards of cultivation in this district have been helpful in the increased production of sugarcane and sugar, can be seen in the following Table.

Table II

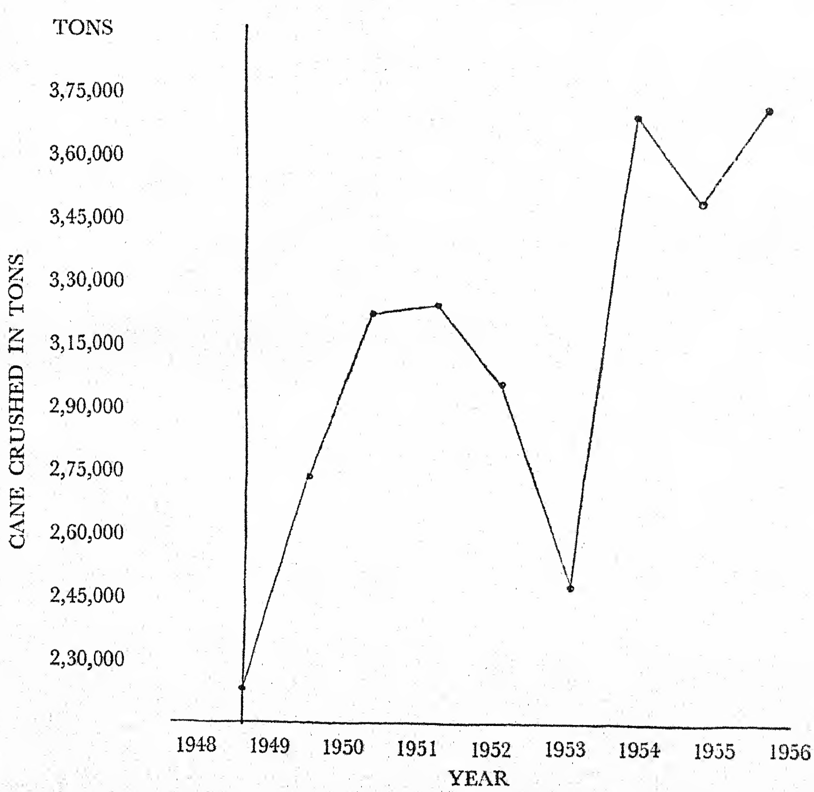
Area under sugarcane utilised by the sugar factory for the supply of canes, the quantity of canes crushed and the sugar made during the years 1948-49 to 1956-57

Year	Area utilised for cane supply in acres	Total quantity of 'canes crushed' in tons	Total quantity of 'sugar made in' tons	No. of days crushed
1948-49	10,088	2,29,663	20,509	132
1949-50	10,615	2,78,239	25,749	162
1950-51	12,538	3,25,210	29,982	182
1951-52	11,622	3,26,117	28,325	180
1952-53	10,648	3,08,671	27,503	172
1953-54	8,920	2,54,587	23,414	134
1954-55	10,156	3,68,988	32,272	186
1955-56	11,116	3,49,247	29,574	174
1956-57	9,118	3,71,291	33,412	187

It will be seen from the above Table, that the area under cane for supply to the factory has almost remained at the same level of about 10,000 to 11,500 acres (vide graph A) even though the total quantity of cane crushed has increased from 229,663 tons in 1948-49 to 371,292 tons in 1956-57 (vide graph B) and sugar made has also increased from 20·509 tons to 33,412 tons, during the same period i.e., an increase in sugar output of nearly 63 per cent. The lesser quantity of cane crushed during 1953-54 is due to the shorter number of days crushed i.e., 134 days only. In the 1956-57 season the area was only 9,118 acres, but 371,291 tons of cane were crushed and 33,412 tons of sugar was manufactured. It is also worthwhile to note that the factory had been working for about 170 days on an average during each season except in the years 1948-49 and 1953-54.



GRAPH A. Area under Cane from 1948-49 to 1956-57



GRAPH B. Cane crushed in Tons from 1948-49 to 1956-57

The yield of cane obtained by the cane growers in this area during the above period is also furnished below:

Year	Average Yield obtained in Tons per acre
1948–49	22·77
1949–50	26·21
1950–51	25·94
1951–52	27·47
1952–53	29·54
1953–54	28·24
1954–55	25·33
1955–56	36·49
1956–57	38·44

It is seen from the above data that the yield of cane has also shown a marked increase from 22·27 tons in 1948-49 to 38·44 tons in 1956-57 i.e., an increase of nearly 69 per cent.

Adoption of Varietal Schedule

The above marked rise in the yield of cane has been mainly due to the adoption of a systematic varietal schedule and changeover from the poor yielding cane varieties like Co. 281, POJ 2878, Co. 349 etc., that were under cultivation during 1948-49 to high yielding and rich cane varieties like Co. 419, Co. 449 and Co. 527. The area under the different varieties during 1948-49 to 1956-57 is furnished in Table III:

Table III

Area: Percentage in each variety

Year	Co. 281	Co. 349	POJ 2878	Co. 419	Co. 449	Co. 527
1948–49	18·00	48·00	27·00	..	..	..
1949–50	24·00	31·00	31·60	..	..	11·37
1950–51	21.00	29·00	27·00	..	..	22·00
1951–52	14·00	20·00	18·00	..	..	42·00
1952–53	6·00	20·00	8·00	..	4·00	57·00
1953–54	7·00	15·00	7·20	..	6·80	61·00
1954–55	2·00	4·00	..	2·00	16·00	75·00
1955–56	..	..	..	3·00	27·00	68·00
1956–57	..	..	..	3·50	48·30	47·20
1957–58	..	..	..	2·70	57·70	37·00

After the introduction of the rich early cane variety Co. 527 *in the year* 1949-50 the area under Co. 281, Co. 349 and POJ 2878 were gradually reduced and ultimately in the year 1956-57, these varieties were completely eliminated. The other high yielding and rich cane Co. 449 was introduced in 1952-53. Thus during the year 1955-56 the three varieties Co. 419, Co. 449 and Co. 527 occupied the entire area. Co. 449 has a higher sucrose content than Co. 527 and hence the area under Co. 449 has increased by a corresponding

decrease in the area under Co. 527. During the year (1955-56) the sugar factory at Nellikuppam recorded a sugar recovery of 9·0 per cent.

Use of Fertilisers

The cane growers of the South Arcot have always been fertiliser minded and, therefore, they give timely and proper attention to the application of fertilisers to the cane crop. Sulphate of Ammonia is very freely used by the growers and about 200 to 300 lbs. of Nitrogen per acre are given to the crop based on the fertility condition of the soil. The fertiliser is given in three doses. The first dose is invariably given at the time of planting. As fertiliser mixtures, manufactured by authorised and recognised dealers are readily available, the cane growers of the South Arcot district use these fertilisers generally to increase their cane yields.

Conclusion

It could be clearly seen from the data furnished in this paper, how the yield of cane and sugar production in the South Arcot district have increased by nearly 60 per cent without any corresponding increase in the cane area. This is as a result of the adoption of a system of varietal schedule, with high yielding cane varieties, proper cultivation, manuring, irrigation etc. and by the adoption of the improved and scientific methods of cultivation. This achievement has been mainly due to the propaganda and demonstration conducted by the sugarcane research and development scheme which has been running in this State from 1949-50 under the auspices of the Indian Central Sugarcane Committee.

In these days when there is great need for the increase in area under food crops, and there are restrictions for the diversion of areas under commercial crops, the methods by which the maximisation of sugarcane and sugar production have been achieved without any increase in area deserves to be set as an example for adoption by others.

Acknowledgment

The schemes of sugarcane research and development in the Madras State are partly financed by the Indian Central Sugarcane Committee and to which committee my thanks are due for utilising the data.

References

Indian Sugar May, 1954
,, ,, July, 1954
,, ,, Nov., 1954
,, ,, Dec., 1954
Madras Agricultural Journal January, 1955.
Annual Report Sugarcane Development Scheme 1948-49 to 1956-57.
Annual Report Sugarcane Research Scheme 1948-49 to 1955-56.
Run reports of the E.I.D. & S.F. Ltd. Nellikuppam 1949-50 to 1956-57.
Periodical reports and returns from sugar factories in Madras State.
Survey of Sugarcane Research and Development by N.L. Dutt.
Tariff Board Report.

Research Notes

Co. 740, a New Variety showing Promise in Tropical India

IMPROVEMENT of sugarcane through breeding is in progress, at the Sugarcane Breeding Institute, Coimbatore since the year 1912. The early results of hybridisation were spectacular in that most of the indigenous canes in sub-tropical India and the exotic varieties in the tropics were rapidly replaced by the superior hybrid seedling canes—the Co. canes—bred and released from Coimbatore year after year. As usually happens in later stages of crop breeding, a phase has been reached since the thirties when the replacement of old improved varieties by new ones has been relatively slow.

In tropical India, Co. 419, selected from a cross between two famous canes, namely, POJ. 2878, the wonder cane of Java and Co. 290, once a cane of promise in several parts of India, was released from the Sugarcane Breeding Institute in the year 1933. As a result of its outstanding performance in all the State Research Stations in tropical India, it was soon released for commercial cultivation. It is today the cane 'par excellence' in tropical India occupying the largest area. Among the later releases may be mentioned Co. 449, Co. 475, Co. 527, Co. 678 etc. which are giving a good account of themselves only in certain restricted areas in tropical India.

It is not always that a plant breeder succeeds in producing 'wonder' strains inspite of a careful choice of parents and skillful selection. An overwhelming element of chance is invariably involved. It is to be acknowledged that chance was extremely favourable in the choice of Co. 419.

Photographs of 8 months old clumps of varieties, (1) Co. 419 (left) and (2) Co. 740 (right) grown at Nellikuppam.

Since the release of Co. 419 it has been the constant endeavour of the Sugarcane Breeding Institute, Coimbatore to evolve varieties better than that variety by bringing into play the useful genes present in more and more varieties of sugarcane. It is gratifying to note that such a combination of useful genes has been

accomplished in the new variety Co. 740, a seedling of a cross between P. 3247 and P. 4775, two among the many good strains built up at the Institute, as parents, for special characteristics. Co. 740 is an early and profuse tillering thick cane, selected and released from the Institute in the year 1949, on account of its superior performance as compared to Co. 419, in the test plots. This variety has consistently maintained its superiority over Co. 419 both in tonnage and C.C.S. per acre, as is borne out by the results of trials conducted in various parts of Bombay State as also at Nellikuppam by Messrs. Parry & Co. Ltd., in the Madras State. The comparative data obtained in the places mentioned above are given in the following table.

Comparative performance of Co. 740 *and Co.* 419 *in respect of tonnage and C.C.S. per acre in parts of Bombay and Madras States*

Sl. No.	Place	Nature of crop	Year	Tonnage per acre		C.C.S. per acre	
				Co. 740	Co. 419	Co. 740	Co. 419
			Bombay State				
1.	Padegaon	Adsali	1956–57	52	49	8·89	7·24
2.	,,	,,	1957–58	75	53	10·99	7·69
3.	,,	Pre-seasonal	Average 1956–57 &	68	58	9·32	8·27
4.	,,	Ratoon	1957–58	47	41	6·89	57·3
5.	Akluj	Adsali	1957–58	90	77	..	..
6.	Kopergaon	,,	,,	65	53	..	..
7.	Lakhmapur	,,	,,	43	36	..	..
8.	Kolhapur	Saru crop	,,	39	39	..	..
			Madras State				
9.	Nellikuppam		1956–57	67·23	57·73	7·04	4·98
10.	,,		1957–58	64·53	52·66	6·02	5·08
11.	,,		1958–59	65·88	57·73	6·52	4·98

It will be seen from the above table that Co. 740 has consistently given better performance in respect of tonnage and C.C.S. per acre as compared to Co. 419. It is also reported to ratoon well. In view of its outstanding performance, Co. 740 is fast spreading and replacing Co. 419 in the Bombay State. The mill tests conducted by the Godavari Sugars Ltd., Lakshmiwadi, Kopergaon, have brought out 'the superiority' of Co. 740 both in tonnage and juice quality with 77·25 tons of cane per acre and 14·16 per cent pol. in cane as compared to Co. 419 which gave 65 tons of cane per acre and 13·77 per cent pol. in cane. Co. 740 has now become the major cane on their factory farm replacing Co. 419.

It is reported that Shri Jatchak, Vice Chairman of the Sansor Co-operative Sugar Mills, and a keen sugarcane cultivator in Baramathi, Bombay State, reaped an actual yield of 103 tons per acre with Co. 740 as against 80 tons per acre with Co. 419 in an adjoining field.

It is evident from the foregoing that Co. 740 is a variety of great promise in tropical India and is well worth the serious attention of the testing stations and development departments in the region. It is hoped that this new variety Co. 740 would rapidly spread and enhance the prosperity of the sugar industry in general and sugarcane growers, in particular, in tropical India by virtue of its superior performance as compared to Co. 419:—(Sugarcane Breeding Institute, Coimbatore, Madras).

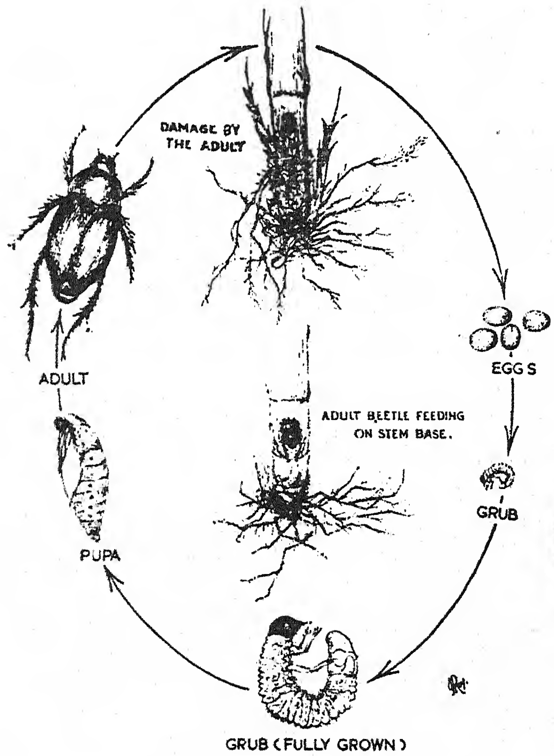
A New Beetle Pest of Sugarcane in Bihar

DURING the past two to three years, white-grubs have become sufficiently abundant to cause serious losses to young crop of sugarcane. Gupta and Awasthy (*Curr. Sci.*, 1957, **26**(4): 114-15 and *Ind. Sug.*, 1957, **7**(9): 587-94) observed severe injury by *Lachnosterna consanguinea* Blanch. The present worker also found that another white-grub pest *Heteronychus* sp. as identified by Indian Agricultural Research Institute, New Delhi, was injurious in the adult stage.

The potential damage that the white-grubs might cause was little realised, as they were seldom very numerous, until they were found to be responsible for heavy destruction of sugarcane at Motihari and Harinagar in the current year. On an examination of an infested sugarcane field in May 1957 and May 1958, the number of adult beetles was found to be 459 and 638 respectively in an area of 100′×4′. The number of adults ranged from 1 to 3 practically underneath each clump of sugarcane in a heavily infested field.

For the most part, there seems to be a definite association between the white-grub damage and soil type. Generally speaking, in South Bihar injury caused by the grubs of *Lachnosterna* Sp. has been observed on sandy soil only (more than 70 per cent sand) whereas the damage caused by the adults of *Heteronychus* Sp. has been reported on sugarcane growing in light loam.

In contrast to *Lachnosterna* Sp., the grubs of which are of economic importance because they feed on the root hairs of sugarcane, the adults of *Heteronychus* Sp., cause extensive damage by underground feeding on stem bases and by boring into the stalks. It appears that the beetle does not injest solid plant material, but rasp the tissues after maceration (Fig. 1). Grubs of this species feed primarily on organic matter in the soil in wet lowlying areas.



HETERONYCHUS SP.

The adults may appear at any time of the year, but usually are more abundant in April and May which is the period of maximum damage to the sugarcane crop. Unlike *Lachnosterna* Sp., they are not attracted to light. They were found copulating beneath the surface of the ground while *Lachnosterna* Sp. come out early in the evening to feed and mate. The female lays her eggs in the soil, which are few in number during the any one 24 hours' period and she continues to deposit for a month or more. The grubs hatching from the first laid eggs attain considerable size before she finishes egg laying.

During this summer a series of preliminary tests were started to obtain information on the value of such insecticides as B.H.C., DDT, Chlordane, Parathion, Aldrin, Dieldrin, Endrin, D-D mixture, Paradichlorobenzene, Ethylene dibromide, Carbon-di-sulphide, mixture of Paradichlorobenzene and Carbon disulphide and Nematox 100. Among these Endrin, D-D mixture Paradichlorobenzene, Ethylene-dibromide, Carbon-di-sulphide, Paradichlorobenzen in Carbon-di-sulphide and Parathion have shown some promise.

Detailed studies on the biology, morphology and control of this pest will be published separately.—(S. K. PRASAD, Sugarcane Research Institute, Pusa, Bihar).

Preliminary Spraying Trials with 'Fungicides against Red Rot'

RED rot is the most serious diseases of sugarcane and a lot of work has been done by Butler (1906), Chona (1950), Abbot (1938) and other workers in India and abroad. Two types of infection i.e. primary and secondary are known since Butler first took up investigations on this disease. He, however, did not give adequate importance to secondary infection which has lately been shown by Chona to cause considerable damage under field conditions. In the Punjab secondary infection to the extent of 50 per cent has been recorded. Realising the importance of this mode of infection Chona devised a method for and initiated testing of the relative resistance of different varieties of sugarcane by the nodal infection method so that the same now forms a regular feature of plant pathological studies at the various sugarcane research stations in India.

It was, however, considered that merely testing of the varieties was not enough and that for obvious reasons means for checking the spread of infection from the leaf midrib lesions should be found. With a view, therefore, to studying the efficacy of different fungicides in immobilising the leaf midrib lesions which are responsible for spreading infection, Khanna (1954) suggested field scale spraying trials which were consequently taken up in different States. The results of such trials conducted in U.P. by Kirtikar *et al.* (1955) have been reported with the observation that "the data give some indication of the beneficial effects of spraying with Blitox and Dithane." The data from Bihar (1957) showed that only Blitox spray brought about two per cent check in the spread of secondary infection. These data, however, did not confirm the findings of the previous year when Spersul and Blitox 50 reduced secondary infection by nearly 25 per cent.

The trials in the Punjab were conducted at Jullundur in 1956 and 1957 on Co. 312 with Perenox two per cent and Fytolan 0·5 per cent. The layout of the experiments was randomised blocks with four replications and each plot had four rows of 20 feet length each. Four sprayings were done beginning with the third week of July at three-weekly intervals. Counts of leaf mid rib lesions were taken in the two middle rows immediately before the first spraying on the 20th July and on the 15th October 25 days after the last spraying. No stalk was found affected with red rot either during the currency of the experiment or at harvest time. The results of the trials are given below:—

Sl. No.	Treatments	Average number of leaf mid rib lesions	
	1956	30-7-56	15-10-56
1.	Sprayed with Perenox 2 per cent ..	914·6	512·8
2.	Control	834·0	1,199·8
	C.D. ±	Non significant	497.6
	1957		
1.	Sprayed with Perenox 2 per cent ..	437·75	396·25
2.	Sprayed with Fytolan 0·5 per cent ..	481·75	402·50
3.	Control	494·75	480·75
	C.D. ±	Non significant	32·36

Perenox Fytolan Control

The data given above indicate that both Perenox and Fytolan significantly reduced the number of leaf midrib lesions. However, they are not sufficiently effective and search for perfect fungicides has to be continued.

ACKNOWLEDGMENT

Our thanks are due to S. Hardial Singh, Economic Botanist Sugarcane, Punjab for his keen interest in these studies which were carried out under the Sugarcane Research Scheme, partly financed by the Indian Central Sugarcane Committee to whom acknowledgments are also due.—(SARDUL SINGH and NAND SINGH, Sugarcane Research, Station, Jullundur Cantt., Punjab).

REFERENCES

Abbot, E.V. (1938) Red rot of sugarcane, U.S. Dept. *Agric. Tech. Bull.* **641**:1-96
Butler, E.J. (1906) Fungus diseases of sugarcane in Bengal. Mem. Dept. *Agric. India. Bot.* **I** (3): 2-24
Chona, B.L. (1950) Studies on the diseases of sugarcane in India. III Ind. *Jour. Agric. Sci.* **XX** (3): 363-85.
Khanna, K.L. (1954) *Proc. 2nd. Bien. Conf. Sug. Res. Dev. workers, India.*
————(1957) Ann. Rept. Sug. Res. Inst. Pusa, Bihar: 325-26.
Kirtikar, *et. al.* (1955) *Curr. Sci.* **24** (8): 277

The I.I.S.R. Sugarcane Inoculator

THE plug method of inoculating sugarcane stalks to test varietal resistance to red rot consists of cutting out and removing a cylindrical core (approximately $\frac{1}{4}''$ diameter and $\frac{1}{2}''$ to $\frac{3}{4}''$ in length) from a healthy stalk, inserting the inoculum in the cavity thus formed and finally replacing the core in its original position. The tool generally used for this purpose is the conventional laboratory cork borer.

CORK BORER

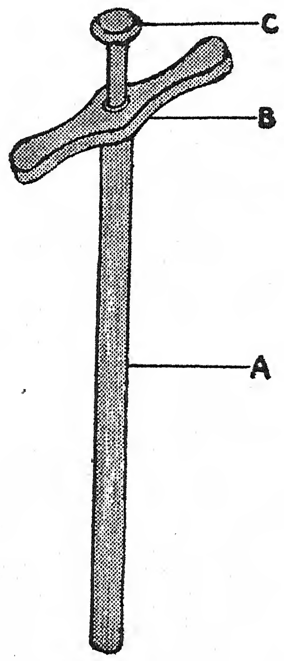


FIG. 1

The cork borer (fig. 1) consists of a stem (A), made of thin-walled, nickel-plated, brass or copper tubing provided with a short handle (B). The cutting edge of this borer gets easily blunted and often curled when worked against the hard rind of the sugarcane stalk and considerably greater physical effort is then required for working the borer into the stalk. The cavity formed is often somewhat lacerated and the plug cut out has an uneven surface with the result that when pushed back into the cavity a snug fit is not obtained. The plug is pushed out of the borer and into the cavity by means of a push rod (C) inserted from the proximal end of the tool. To prevent the push rod from slipping out of the borer and dropping down, it has to be partly withdrawn and held firmly with the base of the thumb while boring the cane and consequently only half the length of the short handle provided can be made to rest against the palm of the hand. The inadequacy of this laboratory appliance for field work which often involves the inoculation of several hundred stalks per day for days on end expresses itself in low out-turn of work, sore palms and frayed tempers.

A cane inoculator (fig. 2) has been designed at this Institute to overcome these defects. This inoculator is made either of medium carbon or stainless steel. The handle (D) provided is designed to furnish a firm and comfortable grip. The push rod (E) is built in and does not slip out of the stem of the inoculator. The

I.I.S.R. Cane Inoculator for Plug Inoculation

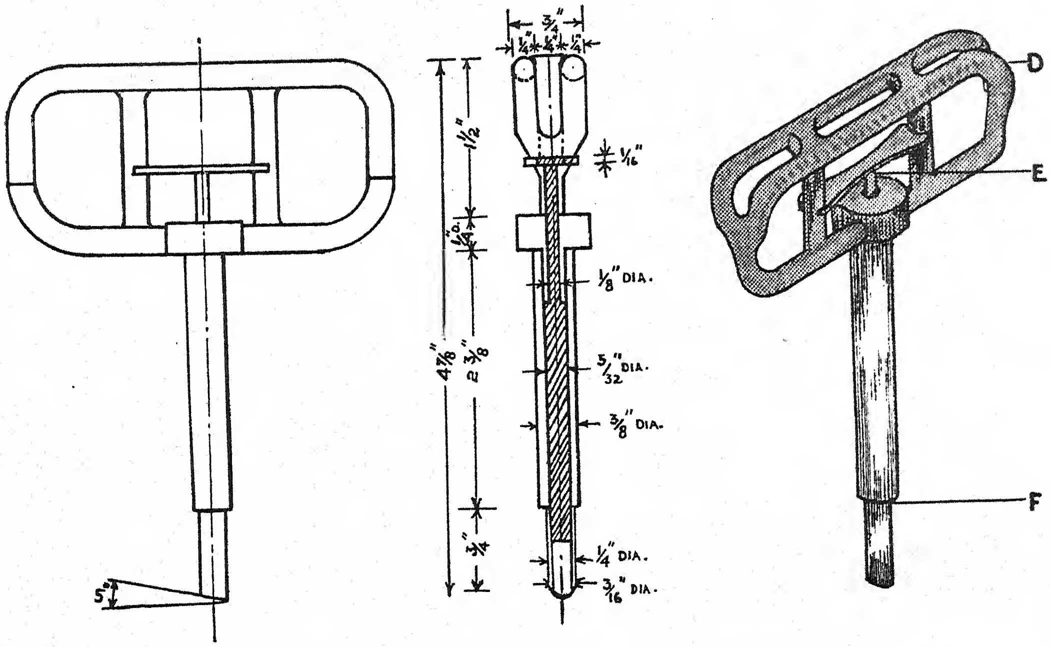


Fig. 2

cutting edge is hardened and tempered and is, therefore, long wearing. Further it is inclined at an angle of 5° to the transverse plane and pierces the cane with much less effort, the cutting being progressive. A step (F) in the stem is provided to ensure uniform depth of the cavities. This improved borer has been tried at this Institute and found to be very satisfactory.—(R. G. Menon and Kishan Singh, Indian Institute of Sugarcane Research, Lucknow, U. P.)

Seminar of the Sugarcane Breeding Institute, Coimbatore

The seventh seminar of the scientific staff of Sugarcane Breeding Institute, Coimbatore met on 25-7-1959. The Director, Dr. N. R. Bhat, presided. Shri R. A. Agarwal, Entomologist spoke on the studies on sugarcane scale *Melanaspis* (Targionia) *glomerata* (Green). He described the work carried out by him on the insect during the last three years.

Shri Agarwal said that the pest is found in a severe form in the States of Madras and Bihar. He described the technique of rearing the insect in laboratory in glass cages and the nature and extent of damage caused by the insect. The variety Co. 745 was found to have suffered heavy losses in weight, sucrose, brix and purity due to its attack. The pest spreads either due to blowing of nymphs by the wind or by the careless transport of the affected canes and seed material. Discussing the life history he observed that there are distinct developmental stages in the case of male insects, whereas in case of female, there were not appreciable morphological changes except that there were no well defined divisions of the body and that there was increase in size after the third moulting. The female took 39-46 days and the male 19-25 days to complete one generation. There are nine generations in a year. The pest can be controlled by spraying 0·04 per cent folidol emulsion after removing the dry leaf sheaths. Of the six parasites found on the scale insect, *Anabrolepis lifiasciata* Ishii seems to be of great potential utility.

He further spoke on the feeding habits of the scale insect. Unlike Aphids and whiteflies, this insect feeds through the parenchymatous tissues. The stylets do not seem to penetrate through the bundles. If the latter happen to be on their way, the stylets curve round the bundles and pass through the parenchymatous cells. The entry of stylets is noticed to be always intracellular. He mentioned that varieties differ in their susceptibility. The *Saccharum spontaneum* variants collected from Assam, Burma and other Far East Countries had been observed to be more seriously attacked. Shri Agarwal mentioned that investigations are being made on the chemical constituents of the scales as also of some susceptible and resistant varieties of sugarcane. He thought it probable that the varieties which were rich in constituents of which the scales are composed may be more susceptible to this pest. Several members of the Institute took part in the discussion that followed.—(Sugarcane Breeding Institute, Coimbatore, Madras.)

Miscellany

IN MEMORIUM

SHRI NAND LALL DUTT

THE sad demise of Shri Nand Lall Dutt on 6th February, 1960 at Madras where he had settled down after retirement (in May, 1958) must have been deeply mourned by all concerned with the sugar industry in India as well as by his numerous admirers and friends throughout the country.

Born in 1900 at Miani (Dt. Shahpur) now in West Pakistan, and after a distinguished career in the Punjab University and the Imperial Agricultural Research Institute, Pusa, specialising in Botany and Plant Breeding, Shri Dutt started service at the Sugarcane Breeding Station (now Institute), Coimbatore in 1926 in the newly created post of the Second Cane Breeding Officer and was the Head of the institution from 1942 till his retirement in 1958.

Throughout his career at the Institute, Shri Dutt devoted himself wholeheartedly to the task of evolving superior sugarcane varieties suited for cultivation in different parts of the country and of investigations in the allied fundamental aspects. He believed in intimate association with the crop and close personal observations as means of developing efficiency in breeding and selection. This together with his unabated enthusiasm for work resulted in a number of improved Co. canes which have very substantially contributed to the stability of the sugar industry in India. Of these, Co. 419, the wonder cane which is grown almost everywhere in South India and Co. 453, the popular late cane of the subtropical belt stand as live monuments to the memory of Shri Dutt. In order to improve the efficiency of the breeding work he started photoperiodic experiments for synchronising flowering in varieties to be crossed and an exhaustive collection of spontaneums from various countries, and established ' the Germ Plasm Bank ' which is the second in the world. He also added the Sections of Mycology and Entomology for help in breeding and selecting disease and insect pest resistant varieties.

Associated with a single crop throughout his career, Shri Dutt initiated studies also on several fundamental aspects of sugarcane, viz., Cytogenetics, Embryology, Floral Morphology and Taxonomy, seed setting and germination, pollen fertility and preservation and contributed over 80 scientific papers. He was elected Fellow of the Indian Academy of Sciences in 1935, and was President of the Section of Agricultural Sciences of the Indian Science Congress in 1947.

In 1944, he was called upon to conduct a Survey of Sugarcane Research and Development in India the findings of which gave a new orientation to sugarcane research and laid the foundation of sugarcane development in the States. He was a member of the Factory Licensing Committee and the *Ad Hoc* Expert Sub-Committee of the Indian Central Sugarcane Committee. In pursuance of his zeal for free exchange of ideas between various workers, he organised the First Conference of Sugarcane Research and Development Workers at Coimbatore. He presided over the Cane Breeding Section in this as well as in similar later conferences during his period of service.

Shri Dutt will perhaps be remembered more for his genial nature with which he built up a large circle of friends. Cricket and Bridge were his favourite games. He was fond of Urdu poetry and English literature. He was a perfect host and extended a warm welcome to all visitors. He was kind and helpful to his colleagues and subordinates and earned their regard and affection.

May his soul rest in peace!

IN MEMORIUM

SHRI SYED ABBAS HUSSAINY

THE sudden demise of Shri Syed Abbas Hussainy, Senior Research Assistant at the Sugarcane Breeding Institute, Coimbatore, on 5th January, 1960 was a shock to his colleagues at the Institute and to many sugarcane research and development workers in the country who knew him.

Shri Hussainy was born in 1900 at Madras and received higher education in the Teachers' College, Saidapet. After serving for short periods in the Madras Secretariat and in the Islamia College at Vaniambadi, he finally joined as Botany Assistant at the Sugarcane Breeding Institute, Coimbatore in 1928. He had enormous zeal for scientific work, more particularly its practical aspects, and in his long service of 31 years, when he worked in collaboration with Sir T. S. Venkatraman and Shri N. L. Dutt, he made many valuable contributions to field techniques in sugarcane breeding. He had a particularly keen eye for selection and identification of varieties and in this field his services proved invaluable. In recognition of his useful contributions, the Government of India were pleased to grant him five extensions, year after year.

He was a good sportsman and had won many trophies particularly in ball badminton tournaments. Being of a genial disposition, he was friendly with all. His sudden end which came about 'in harness' when he had served hardly a few days in the fifth year of his extension, is mourned by one and all who knew him.

May his soul rest in peace !

Publications on Tobacco

Periodicals:

	Single copy	Annual Subscription
"INDIAN TOBACCO" - English Quarterly	**nP. 75**	**Rs. 3·00**
"TOBACCO BULLETIN" - English (Statistical) Quarterly	**nP. 50**	**Rs. 2·00**
"TAMBAKU" - Hindi Quarterly	**nP. 25**	**Re. 1·00**
"POGAKU" - Telugu Quarterly	**nP. 38**	**Rs. 1·50**
"TAMAKU" - Gujarati Quarterly*	**nP. 38**	**Rs. 1·50**

Advertisements are accepted for publication in all the above-mentioned periodicals.

TOBACCO DIRECTORY containing names and addresses of whole-sale dealers, commission agents, grower-curers, warehouse-keepers, manufacturers and exporters handling 2,000 mds. or more of different varieties of Indian tobacco, prominent tobacco growers, tobacco growers' and traders' associations and co-operative societies, importers of Indian tobacco in different countries, Indian Government Trade Representatives abroad and Trade Representatives of Foreign Governments in India, is to be published shortly.

Advertisements are accepted. Advertisement tariff can be obtained on request.

Pre-publication price: Rs. 15 (Rs. 2/- postage extra)

INDIAN TOBACCO ATLAS contains 45 maps, histograms and graphs showing centres of tobacco cultivation, research, marketing etc. and covering all aspects of Indian tobacco production, industry and trade including the trend in tobacco trade in major tobacco exporting and importing countries of the world.

Price Rs. 17·00 (Rs. 1·50 postage extra)

PROCEEDINGS OF THE SECOND CONFERENCE OF TOBACCO RESEARCH WORKERS IN INDIA, DECEMBER, 1959.

Price Rs. 3·25.

Attractive terms are offered for advertisement agents, book sellers and news agents.

For copies and other particulars, please write to:—

The Secretary, Indian Central Tobacco Committee, No. 122, Mount Road, Madras—6

**Correspondence and remittances relating to the Gujarati Journal should be sent to:—*

The Director, Institute of Agriculture, Anand (W. Rly.)